The Dock and Harbour Authority

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Editorial Comments

Glasgow and the Clyde.

Glasgow, second city in the United Kingdom and fourth in rank within the limits of the British Empire, is this year the scene of an outstanding Exhibition, at which all the varied products and manufactures of the Empire are displayed for the instruction and admiration of her citizens and of the visitors who are welcomed within her gates. This bold and courageous enterprise, involving an outlay of something like ten millions sterling, has demanded far-seeing and widespread preparation, together with the energetic co-operation of numbers of local firms of standing and repute. Its successful achievement is, accordingly, a matter of warm congratulation to those responsible for its conception and materialisation. At the time of writing, already more than five million people have come from all parts of the globe to view the result of these labours and before the Exhibition closes in October, the number will be swelled to much larger dimensions.

Advantage has been taken of this unique opportunity to assemble various conferences on matters of public interest and, among them, there has been held in the closing days of June an important International Engineering Congress, promoted by the ten leading technical Institutions of Great Britain and attended by delegates from no less than twenty countries. This step was peculiarly fitting, seeing that Glasgow is essentially a shipbuilding and manufacturing community, and can provide in itself abundant scope for the demonstration of engineering operations and processes which are in the forefront of modern mechanical science. Among the papers read during the proceedings of the Congress was one by Mr. A. C. Gardner, the Chief Engineer of the Clyde Navigation Trust, on the River Clyde and the Harbour of Glasgow.

In view of the prominent position of the Port of Glasgow as a great shipping and commercial centre, the cradle of many of the world's largest liners and the place of origin of craft and plant of all descriptions used in connection with dock and harbour work, it has seemed appropriate to give Mr. Gardner's Paper the distinction of reproduction as the leading article and illustrated Supplement of this month's issue of this Journal. Moreover, it is some sixteen years since we published a detailed account of the activities of the port, and a good deal has happened in the meantime. We are sure, then, that our readers will welcome the account which is to be found elsewhere in these pages of the important developments which have taken place within recent years.

Glasgow, a Royal Burgh, a City and a County of a City, is by far the leading commercial and industrial metropolis of Scotland, with a municipal area of over 30,000 acres and a population rapidly nearing a million and a quarter people. It sits astride the River Clyde, utilising both banks for the development of its great shipbuilding industry. In turn, there has been built in the closely adjacent shipyards, the largest of the world's great liners, including the "Queen Mary" (73,000 gross tons) and the "Queen Elizabeth" (85,000 gross tons), the latter well forward on the stocks and rapidly approaching completion.

As a port, Glasgow ranks among the twelve principal ports of the United Kingdom, with a total net tonnage of shipping, entering and clearing, of over 15,000,000 tons per annum. There is something very remarkable and worthy of the highest admiration in the way in which the Clyde, which a century ago was relatively an insignificant waterway, has been converted from a shallow stream into an important navigable highway, capable of receiving deep-draughted vessels of considerable tonnage. Great credit is due to the successive engineers who planned and carried out the series of deepening and widening operations, which have enabled the Clyde to develop its accessibility and accommodation and Glasgow to take a high place in the commerce of the world.

The Empire Exhibition.

Before leaving the subject of Glasgow and the Clyde, it may be appropriate to add a word on the Exhibition itself, to which attendance at the sessions of the Engineering Congress enabled a visit to be paid. The range of exhibits is extensive, and there must be few to whom, in one or other of its numerous aspects, the Exhibition does not make an appeal. Naturally, the attention of readers of this Journal would be attracted more particularly to two of the pavilions: The Palace of Engineering and the Pavilion of Industries, Shipping and Travel. The former was devoted to all kinds of plant and appliances, including some cranes and conveyors, applicable to quayside purposes, but its main feature was a fine array of shipping models, shown by a number of shipbuilding firms. The Pavilion contained some interesting exhibits by the Clyde Navigation Trust, the Mersey Docks and Harbour Board and the Southern Railway Company. A model of the Meadowside Granary is the chief attraction at the Clyde Navigation stand; though attention will also be given to the tall central pylon, supporting at the summit a Viking ship, with water falling into a basin having a mosaic map with Glasgow at the centre. The Mersey Dock Board's exhibit is a working model of the Gladstone Dock system, containing 18 vessels, several of them manœuvring in and out of the dock. The ease with which, automatically, the dock gates open and close and the vessels reach and leave their berths is sufficient to make a dockmaster envious of the simplicity of the operation! The Southern Railway showed a working model of the King George V Graving Dock and a complete model of the Southampton dock system. There was also a film in operation. The South African Pavilion likewise contains models of South African harbours, which serve as effective miniatures of the features of the respective ports.

Spanish War-time Port for British Ships.

The proposal of the Burgos authorities, in effect General Franco, to establish at Almeria a safe port for British shipping is interesting. The Prime Minister, referring to the matter in the House of Commons on July 7th, said that examination of the suggestion revealed certain difficulties, such as a deficiency in the facilities proposed for the discharging of vessels and communication with the rest of Spain. As regards the harbour itself, the Shipping World Year Book describes it as "a safe port, where vessels of all sizes can enter and load." The depth is given as 35 to 40-ft. at the entrance, and at the quay (900 yds. long) 14 to 22-ft.; at the East Mole (365 yds.), 25 to 30-ft.; and at the West Mole (220 yds.) 20 to 35-ft. There is direct rail communication with Madrid. The situation of the port at the South-east corner of the Iberian peninsular would, however, appear to make transport of cargo to Catalonia and Barcelona difficult and costly. Perhaps this is what General Franco's advisers had in mind in making the proposition.

Editorial Comments—*continued*

New Entrance Lock at Goole.

The Port of Goole was en fête on July 2nd on account of the opening by Sir Josiah Stamp (henceforth, we learn, to be known as Lord Stamp, of Shortlands) of a new entrance lock, 375-ft. long, 80-ft. wide, and with 25-ft. of water over the sill at high water, capable of receiving vessels up to 4,000 tons. The new lock has been named the Ocean Lock, and the first vessel to pass through was the " Dearne " of the Goole Steam Shipping Company on her weekly voyage to the Continent.

Among prominent innovations is the lighting system by means of sodium-type, electric discharge lamps. This kind of lighting is claimed to give the maximum degree of visibility, and in fog and rain has greater penetrating power, which is a very essential requirement at dock entrances where the atmospheric conditions are often a serious handicap to the efficient manœuvring of vessels. The favourable result will be further aided by electric signalling apparatus, so that there should be little difficulty in future in handling craft in and out of dock.

At the opening ceremony, which was attended by local dignitaries and by well-known business men connected with the West Riding of Yorkshire, both Sir Josiah Stamp and Mr. J. R. P. Warde Aldam, the deputy Chairman of the Aire and Calder Navigation, alluded to the remarkable development of the port during the past hundred years. In 1820, Goole was a village with a population of 450; to-day, it is a busy modern town with 20,000 inhabitants. The Navigation was founded two-and-a-half centuries ago, at a time when land communication with the sea was confined to pack horses, and the Port of Goole was developed so that the West Riding industries might have access to the sea at a point as far inland as possible.

The Aire and Calder Navigation are to be congratulated on the present notable addition to the facilities of the port, which plays so important a part in the traffic of the Lancashire and Yorkshire coalfields.

Capetown and the Oil Trade.

The increase in the tonnage of fuel oil bunkers at Capetown during the past few years is sufficiently striking to call attention to the development which is taking place in the character of the functions of the Table Bay Harbour. Capetown occupies a strategic position for fuelling on the trade routes between Europe and India, the East Indies and Australia, as also between these last-named countries and the United States. It is true that it shares this privilege with Durban, but Durban, from its proximity to the coal-fields of Natal and the Transvaal is essentially a coaling port. Capetown, on the other hand, has no such advantage, and is naturally doing its utmost to foster its oil trade, with the result that in the past three years its bunkering output has increased fivefold. In 1934, some 40,000 tons was supplied to shipping; last year the figure had risen to 208,000. The increase is readily accountable for by the growing use of fuel oil in place of coal by shipping; the great reduction in port dues at all Union ports, which came into force in February, 1937, attracting vessels which formerly did not call; and, lastly, by the diversion of shipping to the Cape route, in consequence of unsettled conditions in the Mediterranean.

Extensive enlargements in the accommodation and storage facilities for oil have been made by the responsible authorities, and a new depôt is being formed at Yserplaatsvlei, about a couple of miles to the eastward of the new harbour, now in course of construction at Table Bay. Six of the largest tanks (13,500 tons capacity each) in Africa are to be located there, bringing the total fuel oil storage capacity up to 128,800 tons.

The indications are that considerable scope exists for still further developments in this important trade, and that Capetown will occupy an even more prominent position in the future as an oil-port.

Transport Nationalisation.

For a good many people nowadays, the idea of nationalisation exercises a peculiar fascination. Extreme partisanship makes them eager to promulgate it in connection with almost every branch of industrial or commercial activity. It dominates their outlook, to the exclusion of all relevant adverse considerations. They imagine, in fact, that it represents the summum bonum of modern civilisation. Most forms of public service have, at one time or another, been advocated as suitable for exploitation under direct government control, and, quite recently, banks have been added to the list, even if, as Sir Stafford Cripps has admitted, the attainment of the object would involve " a first-class financial crisis."

The latest outburst on the subject is the resolution passed at the annual conference on July 5th, of the National Union of Railwaymen, the terms of which are sweeping enough to comprise all forms of transport, by road, rail, air and sea, including, we suppose, such essential adjuncts to the last as docks and harbours. The terms of the resolution, which was carried unanimously, were as follows:—

" That the time is ripe for the complete co-ordination of the transport system of Great Britain under public ownership and control, having regard to the dependence of the nation's economic life upon an adequate transport service which cannot be provided under the present wasteful competitive system."

Ignoring the questionable propriety of the epithet applied to the existing order of things and the unsupported assumption that the new state of affairs would be a certain remedy for all its alleged defects, it may pertinently be asked whether the basic reason for the desired change does not really lie in the fondly cherished belief that nationalisation means simply and without effort, higher wages, fewer working hours and (possibly) a less stringent degree of supervision. The General Secretary of the Union, as reported in the press, while disclaiming that the railwaymen had any desire " to improve their condition to the detriment of the general public," did not disguise the conviction that "co-ordination would bring better standards of wages," as well as other things, " provided the interests of the financiers were not made the first consideration." The " financiers " are, of course, as always, the bugbear!

Politics and social economics are not the province of this Journal, but from the point of view of efficiency in operation, as envisaged in the light of the experience of ports in certain other (non-dictator) countries, where national or government control prevails, we may be permitted to express our doubts as to the wisdom of the proposal.

British Shipbuilding Returns.

The statistics issued by Lloyd's Register of Shipping regarding merchant vessels under construction at the end of June, show a further decline of the orders in hand at British shipyards as compared with the figures for the preceding quarter. The present decrease is 52,000 tons; at the close of last quarter, the decrease was about 36,000 tons. There is, therefore, an accumulating deficit in the standard of output, which serves to intensify the misgivings entertained in responsible quarters as to the adequacy of the British mercantile marine to meet the strain of another submarine campaign. A recent debate in the House of Commons showed that no satisfactory answer to the question has yet been given, the attitude of the President of the Board of Trade being, in plain terms, helplessly evasive. Passing the responsibility for the solution of the problem on to the shipping industry and inviting it to submit proposals for sympathetic consideration hardly meets the requirements of the case, by reason of the duality of the interests involved, viz., commercial prosperity and national defence. Very careful and concerted investigation will have to be undertaken by the Government with the shipowners, if effective measures are to be devised to meet a situation which is distinctly perturbing.

Stress has been laid on the point that the cargo-handling equipment of British ports is relatively more efficient and of greater capacity than in 1914, and that this will compensate, in part, for the reduction in shipping tonnage. Yet, admitting the contention for what it is worth, the liability to disablement and destruction by air attack rather discounts any consolation to be derived from this source. Ships, too, are larger than before, but a well-directed torpedo would serve to put out of action a correspondingly larger tonnage unit. Altogether, the problem is a difficult as well as a serious one. It demands urgent attention.

Factory Regulations in Docks.

The Factories Act, 1937, the greater part of which has recently come into operation, has an important bearing in a number of respects on dock and harbour operation. Port Authorities will do well to acquaint themselves with its provisions, and although a detailed study of the Act would perhaps best be undertaken with the help of a solicitor, yet there are cases in which a lay officer may find it necessary to make himself personally conversant with the scope of the new enactments. Accordingly, we have provided on another page of this issue a general guide by our legal correspondent to enable reference to any particular section to be readily traced. The continually increasing requirements of modern safety regulations, while they are to be welcomed in the interests of industrial employees, involve additional responsibilities for employers, including port authorities.

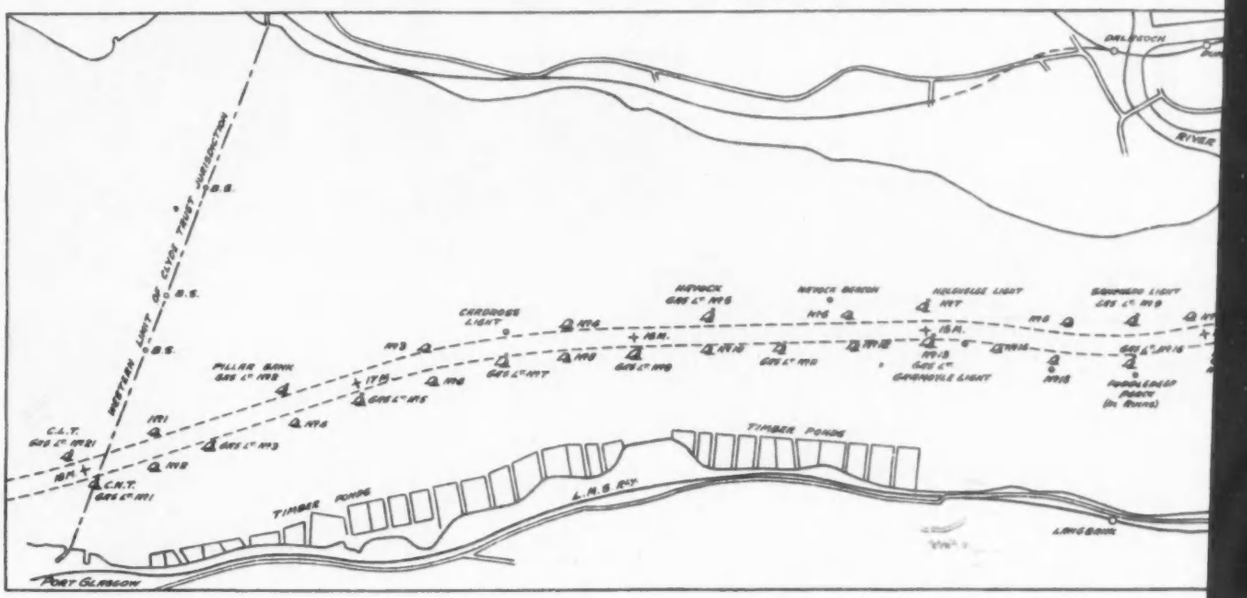
Corrigendum.

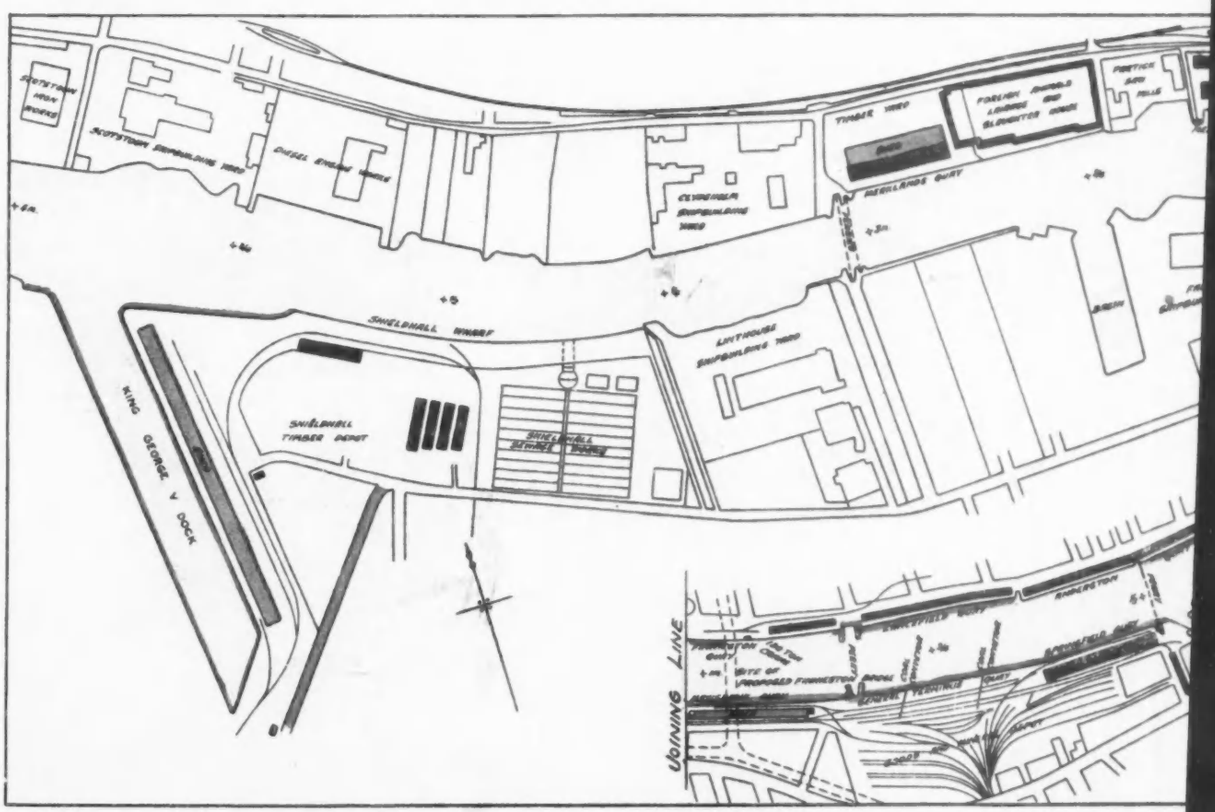
On page 278 of the preceding issue, in connection with the article on The Yangtse Estuary, the words N. Fork and S. Fork have accidentally been transposed in the diagram of the Longitudinal Profile of S. Channel Bar.

XUM

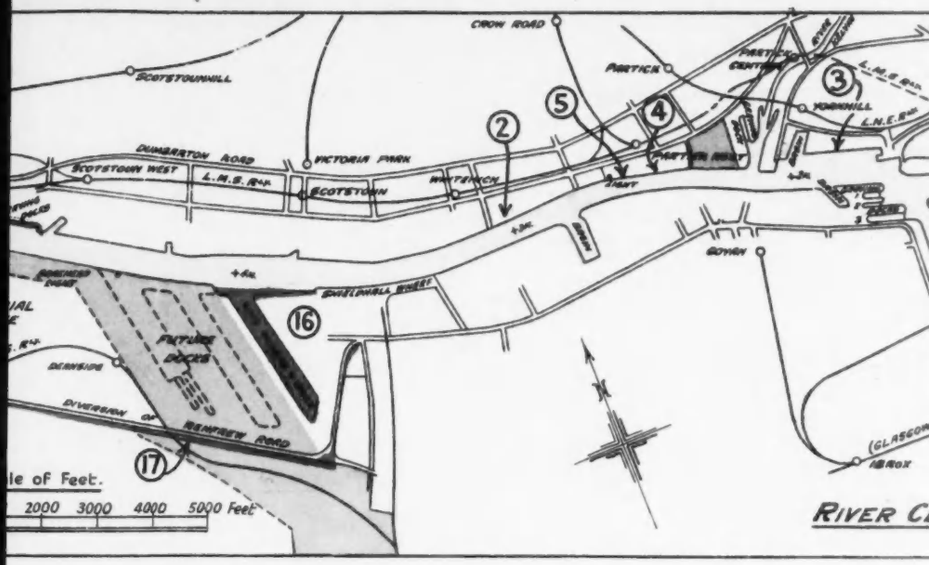
— THE RIVER CLYDE —
— AND THE —
HARBOUR OF GLASGOW.

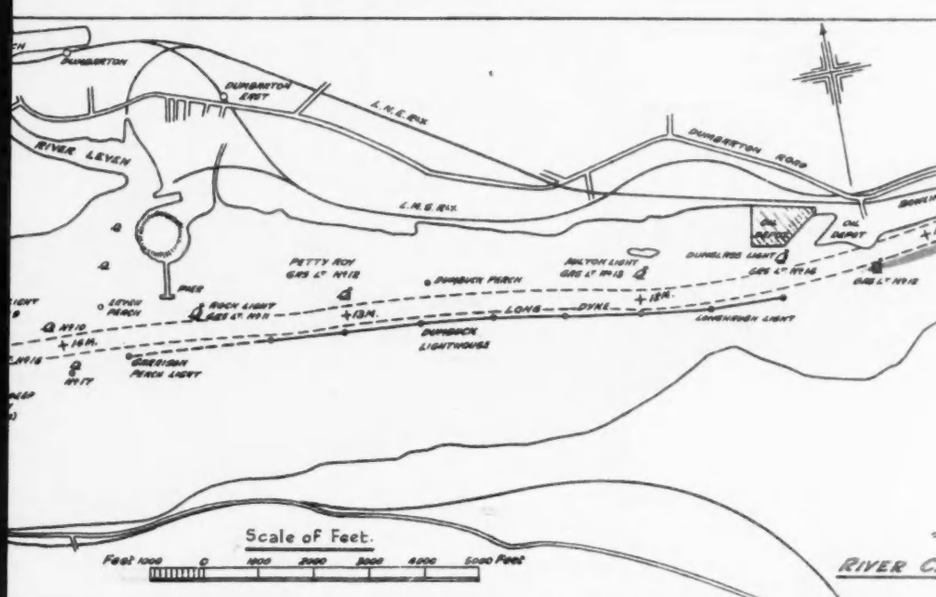
ENGINEER-IN-CHIEF;-MR. A.C. GARDNER, F.R.S.E., M.INST.C.E., M.I.MECH.E..

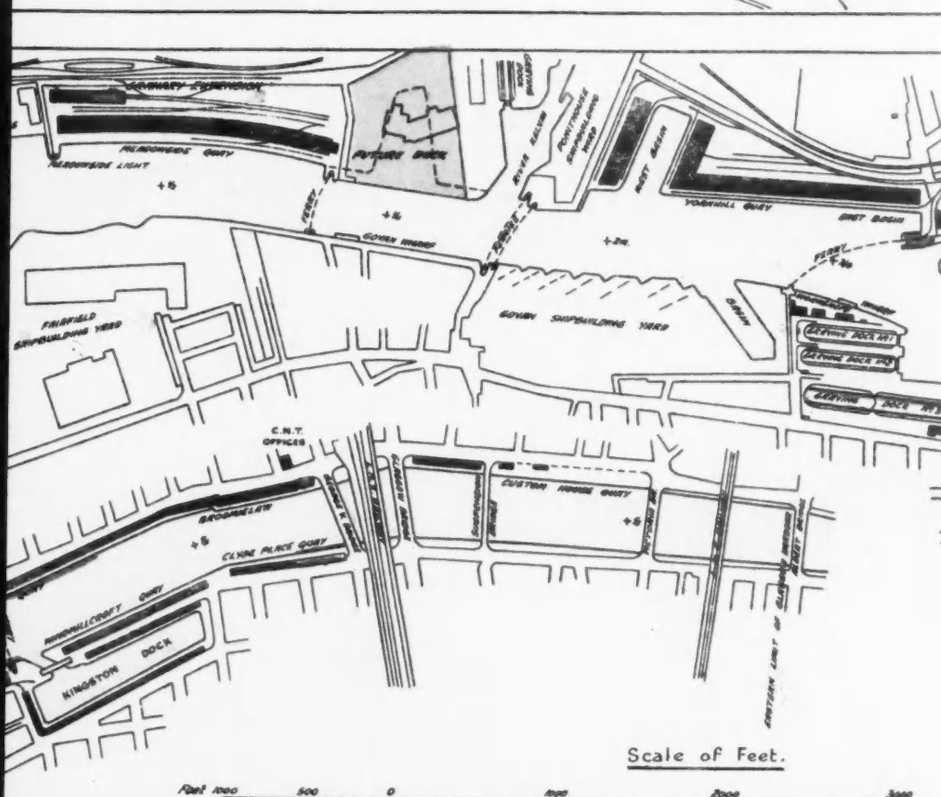




AND HARBOUR AUTHORITY, AUGUST 1938.







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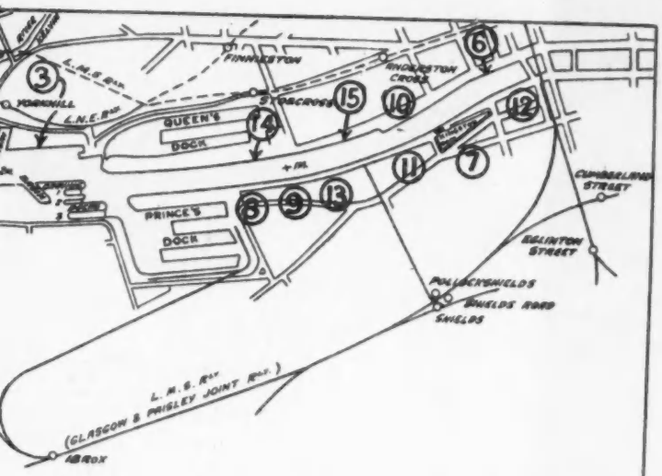
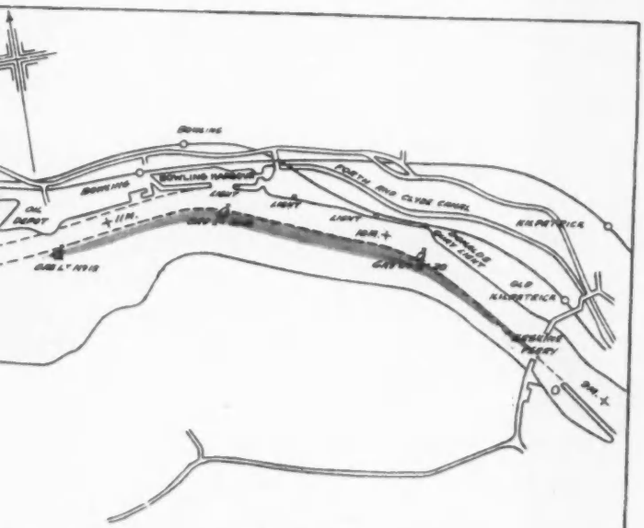
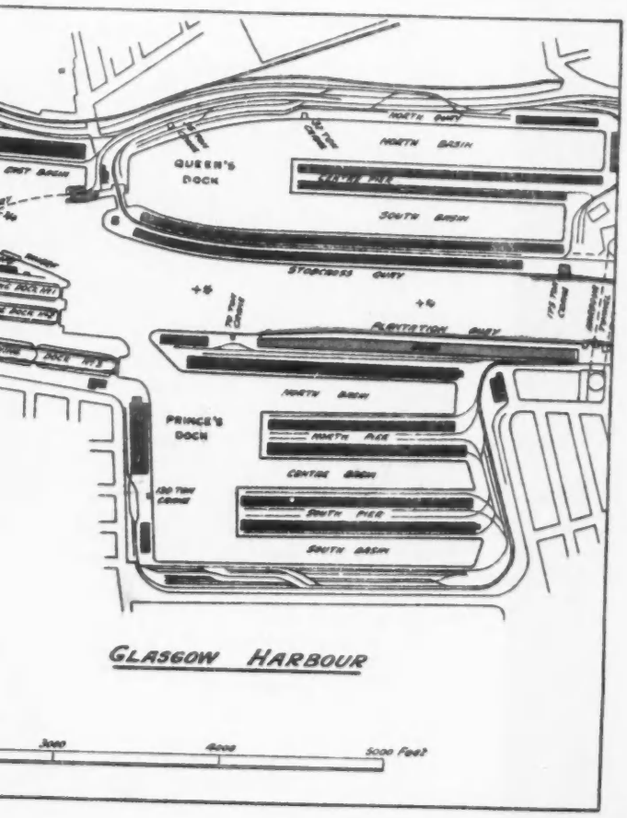


RIVER CLYDE — GLASGOW TO ERSKINE FERRY



RIVER CLYDE — ERSKINE FERRY TO PORT GLASGOW



GLASGOW HARBOUR

The River Clyde and the Harbour of Glasgow*

By A. C. GARDNER, F.R.S.E., M.Inst.C.E., M.I.Mech.E.
President of the Institution of Engineers and Shipbuilders in Scotland

THIRTY-SEVEN years ago, when the last International Engineering Congress was held in this City, the author's predecessor in the office of Engineer to the Clyde Navigation Trustees addressed the Congress on "The River Clyde and the Harbour of Glasgow." His address dealt, among other things, with the early history of the river, and the first successful attempts, in the latter part of the eighteenth and the beginning of the nineteenth centuries, to improve the navigation by those engineers whose pioneer labours transformed the River Clyde and wrote the first chapter of its commercial history. It reviewed the various Acts of Parliament authorising the subsequent deepening and improvement of the river, and included a general survey of the harbour undertaking as it existed at the beginning of the present century.

A. C. GARDNER,
F.R.S.E., M.Inst.C.E., M.I.Mech.E.

In this paper it is proposed to carry on that survey, and to recount the steps which have been taken since that time towards the further improvement of the river and the enlargement of the port. The Supplement of the River Clyde shows the present state of the undertaking, and the character and location of the principal changes which have been made during the last thirty-seven years. It is to these improvements in their wider engineering aspects that it is proposed to refer, in the order in which they are numbered on the Supplement.

Improvements in Quays and Docks

In 1900, all the quays and docks of the Harbour of Glasgow under the jurisdiction of the Clyde Trustees were situated within a radius of approximately two miles from the centre of the city, and to the east of the River Kelvin, but the control and maintenance of the river westwards to the sea was then, as now, their primary concern and chief responsibility. Since then, the expansion of the harbour has been steadily westwards, ultimately reaching a point six miles beyond the centre of the city, with the opening of Rothesay Dock at Clydebank in 1907, and all subsequent works of any magnitude in the way of new docks, quays, and buildings have been carried out within those territorial limits. The aggregate length of the deep-water quays in the docks and harbour of Glasgow is now over twelve miles, whilst the annual tonnage of vessels entering and leaving the port has risen from 4,360,000 in 1900 to over 15 000,000 tons to-day. The turn of the century had witnessed a new era in the building of large ocean-going ships, when the dimensions previously attained began to be steadily overhauled. This applied not only to passenger liners but to merchant vessels also, in all the leading maritime countries of the world. Such advances in the length and beam of ships imposed, as a result, increasing obligations on the Dock and Harbour Authorities required to accommodate them, and the increasing draught often involved the deepening of existing waterways. All these demands fell to be met in a special degree by the Trustees of the River Clyde, not only as a Harbour Authority, but also as the custodians of a river already challenged in its supremacy as the leading shipbuilding centre of the world.

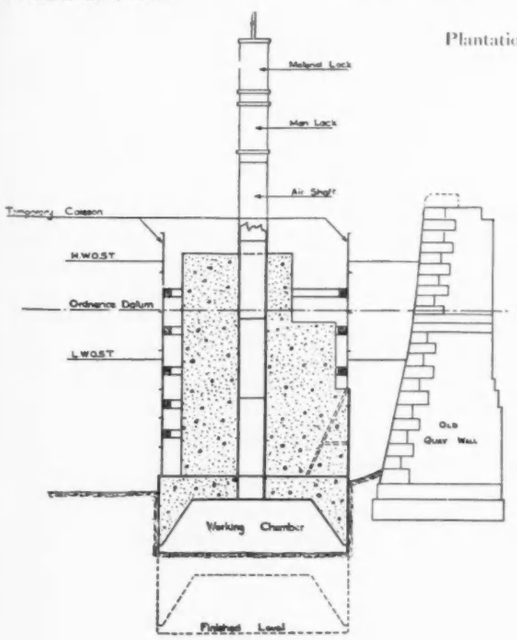
The steadily increasing size of ships was accompanied also by a rapid increase in the general traffic of the port, so much so that the Trustees obtained Parliamentary powers to construct the first of the modern docks on sixty acres of land at Clydebank solely for the purpose of dealing with coal and mineral traffic and thus relieve the pressure in the harbour. This dock (No. 1 on Supplement), which is an open basin with a water area of 20 acres and provided with 2,045 yds. of quayage, is approached from the river by an entrance 200-ft. wide, and has a low-water depth of 25-ft. All the appliances are electrically operated; and when opened to traffic in 1907 this dock was the first in the country to be so equipped.

Concurrently with the construction of Rothesay Dock, the Trustees embarked on a further scheme to increase the accommodation in the harbour, which involved, as a first step, the construction of a deep-water quay at Merklands (No. 2 on Supplement), having a length of 525 yds., on the ground behind which is the Cattle Lairage, built by the City Corporation, but now owned and operated by the Trust. This was followed by the Yorkhill Quay and Basin (No. 3 on Supplement) in 1910, with an additional 1,137 yds. of quayage, and later, in 1912, by the construction of another deep-water quay at Meadowside (No. 4 on Supplement), with a length of 538 yds., to serve the requirements of the granary which was opened in 1914. This building (No. 5 on Supplement), originally constructed for the storage of 31,000 tons of grain, has recently been enlarged, and will be referred to later.

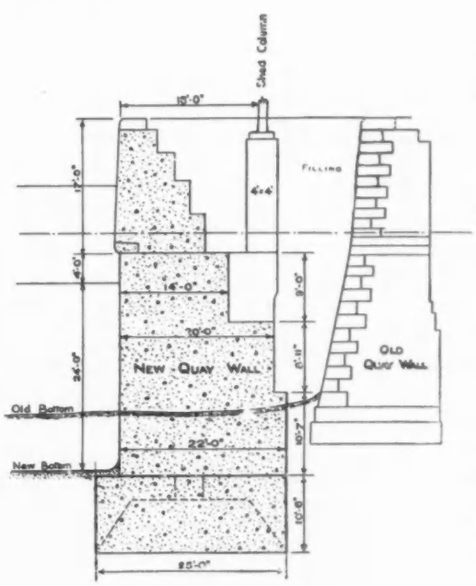
From 1914 onwards the Trustees, having met the immediate needs of the port and its growing traffic, began to rebuild some of the older quays in the harbour and to deepen the riverside

* Paper read at the International Engineering Congress, Glasgow, on June 21st, 1938.

Plantation Quay, East



Caisson Wall during Sinking



Completed Wall

The River Clyde and the Harbour of Glasgow—continued

berths. This work has proceeded more or less continuously ever since, and one by one quays bearing familiar names in local history have been demolished, and replaced by walls of more modern construction to provide deep-water berthage.

Notable among these, and the first to be taken in hand in the beginning of the period under review, was the reconstruction of the Broomielaw Quay (No. 6 on Supplement), and thereafter, in the latter half of the period, were undertaken successively the reconstruction of Kingston Dock (No. 7), the rebuilding of Plantation (No. 8), Mavisbank (No. 9), Anderston (No. 10), Springfield (No. 11), Clyde Place (No. 12), and General Terminus Quays (No. 13), aggregating a total length of 2,900 yds., whilst Stobcross (No. 14) and Lancefield Quays (No. 15), embracing a length of 400 yds., are in course of reconstruction to-day.

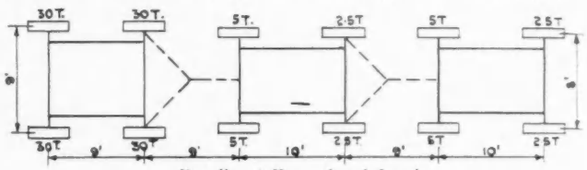
Some of the forms of construction adopted in the design of these walls present novel and interesting features. Others, both in the new and reconstructed works, follow standard forms determined by the known character of the ground, but over comparatively large areas in the Clyde Valley, where there is no consistent geological conformity, all kinds of material are met with, ranging from running sand and gravel to boulder clay and hard basaltic rock. So unexpected, indeed, are the changes in the strata, that in a comparatively short distance it has frequently become necessary to change abruptly from a piled foundation to pneumatic caisson construction, or to have recourse to other methods. Thus it is that in the docks and harbour of Glasgow, the types of construction used embrace a wide variety of form and design, some of which are illustrated in this article.

Glasgow is fortunate in that the maximum tidal range in the river is only 12-ft. 4-in., which renders a closed system of docks unnecessary, so that all the docks on the Clyde are in reality open tidal basins accessible to shipping at all states of the tide.

In circumstances other than those obtaining in the Clyde, which is a canalised river of limited width, formed at great cost and with the labour of many years, the question of the adoption of closed or open basins might have been the subject of much academic discussion.

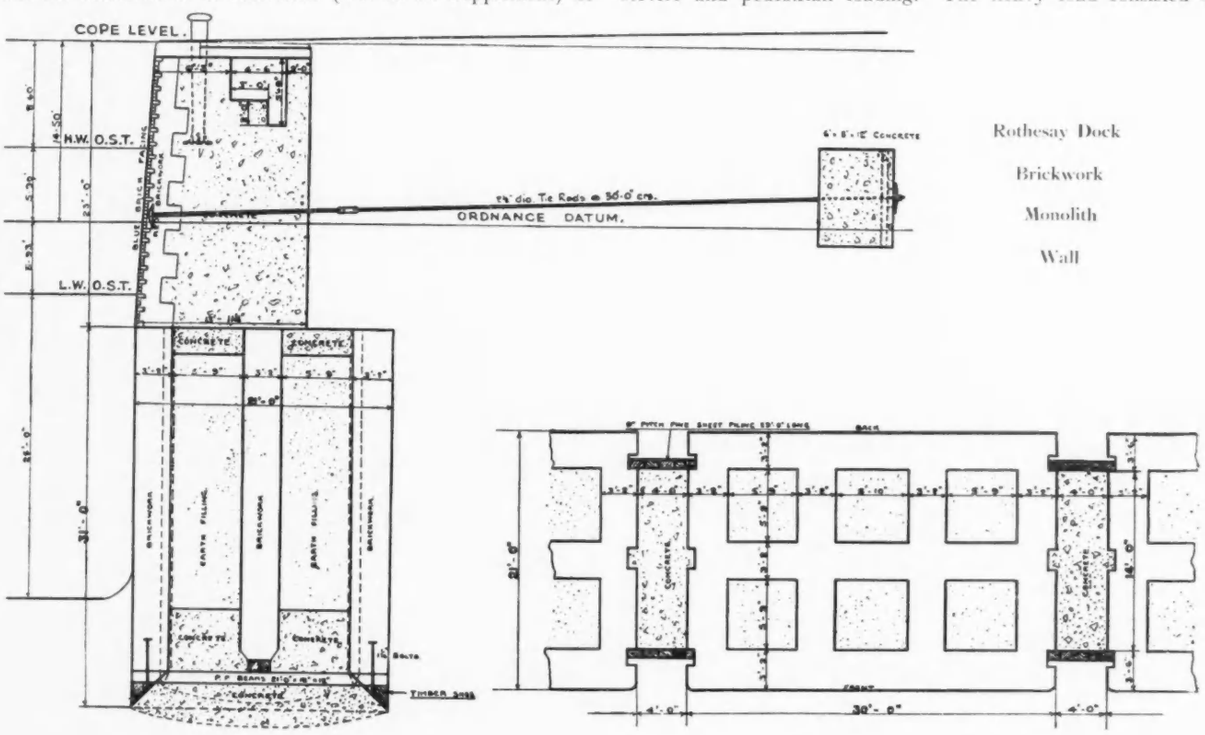
With a closed system of docks, having gates and entrance locks, the initial cost of construction might conceivably have been less, in consequence of the reduced height of the dock walls; but in a narrow river in the heart of an industrial city, carrying an ever-increasing burden of shipping, the inevitable delays arising from vessels entering or leaving through lock entrances would have involved serious traffic congestion, and, as events have transpired, would have required the construction of costly lay-by wharves for the accommodation of vessels waiting to enter. These considerations, added to the need for canting areas within the docks—areas which are now available in the river at the open and wide entrances of all the basins—have more than justified the adoption of the open dock system on the River Clyde.

The largest work carried out by the Trustees in recent years was the construction at Shieldhall (No. 16 on Supplement) of the new King George V Dock, so named by Her Majesty Queen Mary, who, with the late King George V, opened it in July, 1931. This dock is situated on the south bank of the Clyde, between Renfrew and Shieldhall, on land having a river frontage of nearly two miles. The completed scheme of development, as shown on the Supplement, will comprise a series of three parallel basins set at an angle of 55 degrees to the river, and a deep-water quay, 1,450 yds. in length, on the riverside to the west, which will add about four miles of quayage to the harbour. The whole scheme is set back from the south bank of the river in order to secure ample width for the canting and manœuvring of large ships. Two of the basins, including that already constructed and in use, have a width of 350-ft., whilst the third basin, to the west, is designed to have a width of 500-ft., terminating at its southern extremity with two graving docks to accommodate the largest vessels likely to use the Clyde.



Details of Exceptional Load

The insistent demand for increased deep-water berthage in 1923 decided the Trustees to embark on the first phase of the project, which involved the diversion of the Glasgow-Renfrew Road (No. 17 on Supplement) as the initial work preparatory to the construction of the first dock. The work was commenced in September of that year, and the new road was opened to traffic in March, 1926. The diversion encloses the area to the west and south, linking up with the town of Renfrew on the west. The total length of the diverted road is about $1\frac{3}{4}$ miles, and the portion parallel to the river is 80-ft. in width, joining up at its eastern end with the new trunk road constructed by the Corporation of Glasgow. For the greater part of its length the road is carried on an embankment, the material for which was taken from the excavation for the dock. The elevation of this roadway, which bounds the dock estate, was necessary in order to obtain the requisite headroom for the railway lines leading to the new quays. For the accommodation of the railway connections three bridges were built, the east and west bridges spanning four double lines, and the centre bridge two double lines of railway. All three bridges are of ferro-concrete, and, except for the east abutment and the two eastern piers of the west bridge, where boulder clay provided a suitable foundation at a reasonable depth, all the piers and abutments were founded on piles, which at the east and centre bridges were from 75 to 85-ft. long. The bridges were designed to carry an exceptionally heavy load in addition to the deadweight of the structure, and in conjunction with the normal tramway-car service and pedestrian loading. The heavy load consisted of



Cross Section

Plan

Rock-breaker at Work in the River Clyde

King George V Dock East Roundhead at Dock Entrance

King George V Dock—Dredging Basin

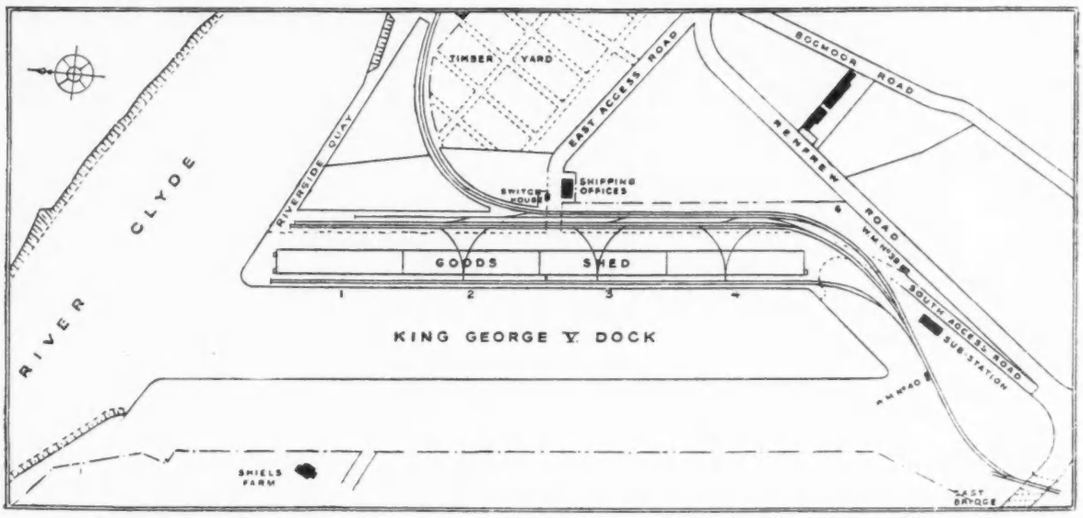
King George V Dock Monolith Sinking

The River Clyde and the Harbour of Glasgow—continued

an occasional moving load of 120 tons carried on two axles 9-ft. apart, with a gauge of 9-ft., drawn by a train of tractors of 15 tons each, as shown in the diagram on page 284.

In the calculations for the design of the bridge floors, an addition of 20 per cent. was made to the foregoing figures to allow for impact.

All three bridges are designed on similar lines, the abutments consisting of counterforted walls, the counterforts being 1-ft. wide at 10-ft. centres. The wing walls, as distinct from the abutments, which are heavily piled, are carried on raft foundations, and expansion joints are provided between them and the abutments to allow of unequal settlement. Expansion joints are also provided between the decking and the abutments to allow the decking to expand and contract under temperature changes. The octagonal columns of the bridges are of reinforced concrete and are located under the main deck beams, which are 4-ft. deep and 2-ft. wide, placed at 10-ft. centres, with a 12-in. floor slab between them. Provision is made under the pavements of the bridges for the accommodation of electric cables, gas mains and other services, whilst cantilever troughs outside the parapet beams carry the water mains. The water mains, 24-in. and 12-in. in diameter respectively, were laid in the roadway by the Glasgow Corporation, and between the bridges are supported on brick piers, built above the original level of the ground before the embankment was made.



The King George V Dock

The easternmost basin of the scheme referred to, known as King George V Dock, is 350-ft. wide and 2,483-ft. long, with a water area of 20 acres, providing a depth of 32-ft. at mean low water, or 44-ft. 4-in. at mean high water of ordinary spring tides. The entrance to the basin is set back about 200-ft. from the bank of the river, and a new wall, extending eastwards a distance of 850-ft. from the north-east roundhead, links up with Shieldhall Wharf, forming a new deep-water riverside quay, as shown on the plan above.

Before the construction works were started, numerous bores which were put down on the lines of the dock walls, revealed that except for a small area at the southern end of the basin, where boulder clay and rock were met with at reasonable depths, the greater part of the walls would have to be founded on sand. A detailed examination of the materials from these bores, in the light of the experience gained from other works in the vicinity, forced the conclusion that monolith construction would be the most satisfactory method for all the walls, except at the extreme southern end of the basin, and even there, in the south wall, it was ultimately decided to adopt the same form of construction at one point where there was a deep depression in the underlying rock strata. The riverside wall to the east of the entrance was founded throughout on monoliths. The total length of wall in all the quays is 6,450-ft., of which 5,601-ft. consist of monoliths, and 849-ft. of ordinary gravity wall constructed in piled trenches. The total number of monoliths sunk was 164, of which four were of a special curved construction at the outer corners of the dock.

The monoliths, which are 30-ft. square, set 4-ft. apart, each contain four excavation wells constructed on steel shoes weighing 15 tons each. The side and division walls are 3-ft. 4-in. thick, constructed of mass concrete to a height of 7-ft. above the cutting edge of the shoe. Thereafter they are built in courses of moulded concrete blocks 2-ft. high, bonded as shown on the diagram, and built in cement mortar, the normal total height of each monolith being 44-ft.

In order to stiffen them during sinking operations, the three lowest courses of blocks were tied to the steel shoe by means of 16 vertical anchor bolts, each $1\frac{1}{4}$-in. in diameter. After each monolith was founded in its final position, these walls were filled with 5 to 1 concrete to a height of 7-ft. above the cutting edge of the shoe, and thereafter with 10 to 1 concrete, the aggregate for which was light breeze in the front wells, and heavy slag in the back.

At the entrance to the dock where the roundheads were formed, the curved monoliths are tied to each other, and to those in the adjoining walls, with a lacing of steel rails set in a continuous slab of fine concrete, which in addition was reinforced with steel fabric, the ends of the rails being bent down into the wells for a distance of 2-ft. 6-in., these particular wells being filled with 6 to 1 concrete.

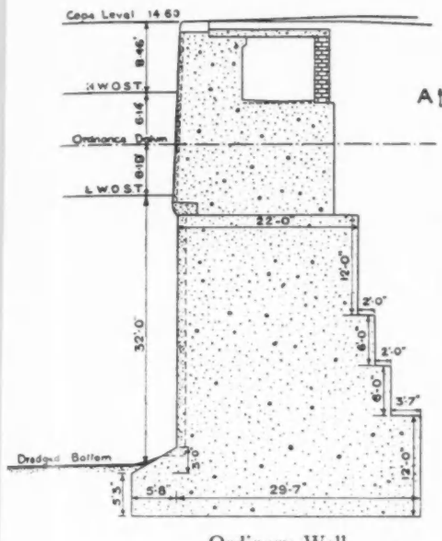
Above the monoliths themselves, the superstructure of the wall above string course level was constructed in mass concrete with a granite cope, and in anticipation that a granary would at some time be required, probably near the south end of the dock, it was considered advisable to build the quay walls with subways suitable for the ultimate installation therein of grain band conveyors, and to leave chute openings in the subway roof. The subway, which extends through all the walls of the basin, was made 8-ft. 8-in. wide and 7-ft. 6-in. high for a distance of 1,000-ft. from the south ends of the east and west walls, to accommodate two band conveyors, one above the other. On the south wall the subway was made 11-ft. 3-in. wide to accommodate two conveyors side by side.

In the course of construction, the sinking through soft clay and sand presented little difficulty when the requisite weight and arrangement of kentledge was maintained, the monoliths being sunk entirely by grab excavation. It was found advisable, however, in a number of cases where the sand had been compacted by the pressure, to assist sinking for the last few inches by exploding charges of gelignite in the wells. Several of the monoliths had to be sunk for considerable distances through stiff clay and boulders, which could not be removed by grabbing. In such cases the wells were pumped out, and sinking continued by manual labour assisted by blasting operations, whilst alternate flooding and pumping served to assist the sinking process. Several "blows" occurred in one or two of the monoliths whilst being sunk through sand, the structure in consequence being thrown out of level, but the monoliths which were most troublesome to sink were those passing through coarse gravel, when this was bound with clayey blaes. The gravel being porous, it was impossible to pump the wells dry, and sinking was therefore done by blasting under water and removing the loosened material by grabs, which proved a long and tedious process. The kentledge used varied from 390 to 1,640 tons, the average being in the neighbourhood of 800 tons per monolith. The rate of sinking varied considerably, but the record rate was established on the west wall, where one of the monoliths was sunk a depth of 52-ft. 2-in. in $9\frac{1}{2}$ working days. This was accomplished with 708 tons of kentledge, the monolith itself at that stage weighing 1,438 tons, or 741 tons after allowing for buoyancy.

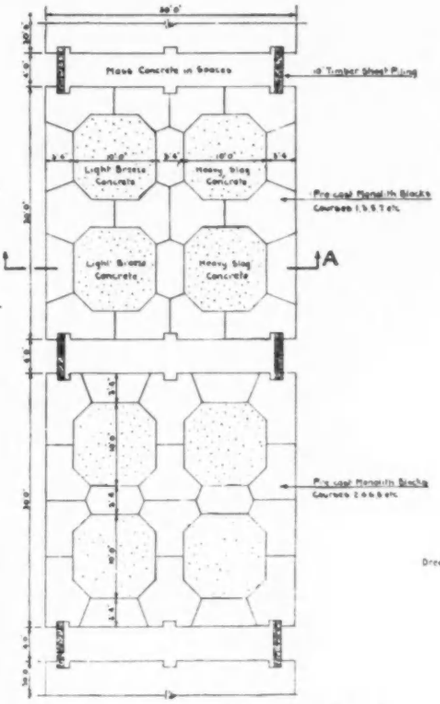
Very few of the monoliths got out of line and level, but the most conspicuous example of this may be of interest. This monolith went down normally through soft material until the eleventh day of sinking, when, with only 222 tons of kentledge, a serious inrush of material occurred, throwing it out of line and level. The kentledge was then increased to 561 tons, carefully distributed, in an effort to assist righting purposes. Sinking by grab was then continued for another five days, when it sank to within 6-ft. 6-in. of its final depth without much improvement in level. At this stage the top projected into the dock $12\frac{3}{4}$-ins. at one end. The kentledge was then increased to 708 tons, its distribution carefully adjusted, and sinking continued,

The River Clyde and the Harbour of Glasgow—continued

KING GEORGE V DOCK

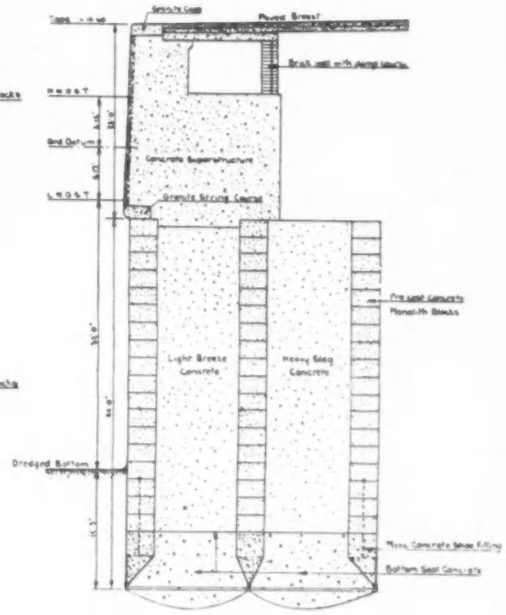


Ordinary Wall

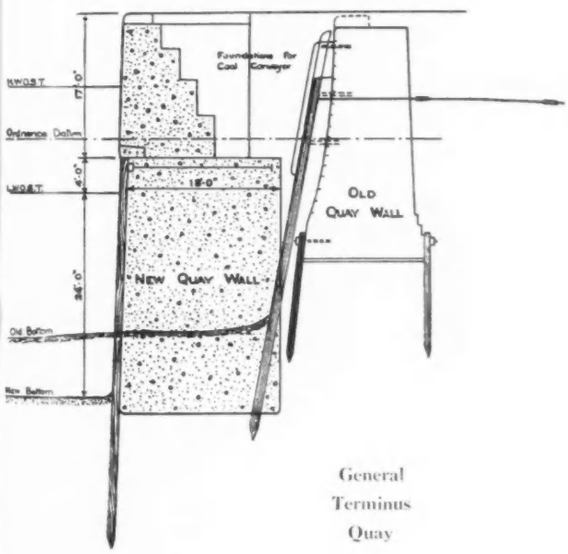


Plan showing Arrangement of Monolith Blocks

DETAILS OF MONOLITH WALL

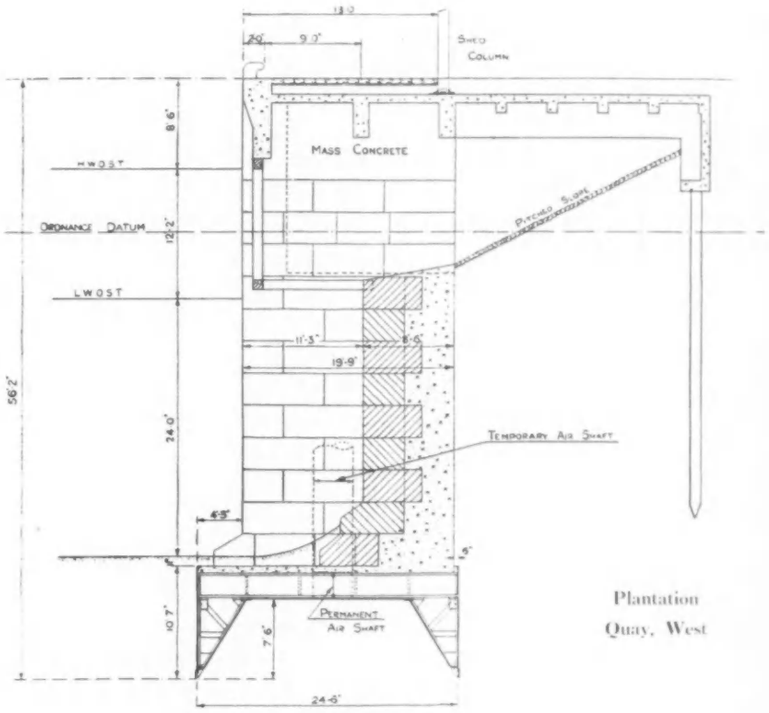


Section A-A



General Terminus Quay

Ordinary Wall



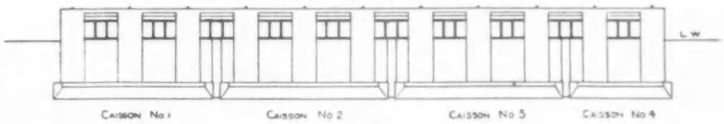
Plantation Quay, West

Section AA

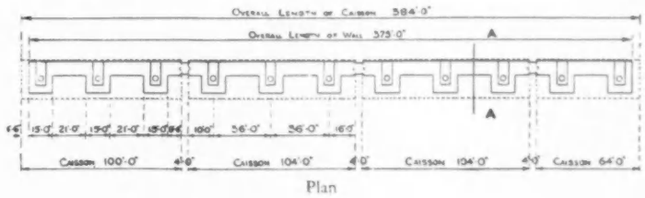
but when brought to its final depth, it was still projecting some 10½-ins. The projecting face, therefore, had finally to be dressed off. The last 9-ft. of sinkage in this instance was through sand and gravel. The case is mentioned to illustrate the danger of insufficient kentledge being used in the earlier stages of sinking, as it is very probable that with sufficient weight, the inrush of material which caused the trouble might not have occurred.

The excavation from all the monoliths and trenches was deposited on the open ground on the site of the dock, the whole of which area, together with the original river bank in front and to the east of it, was removed by the Trustees' dredging plant, and transported by sea to the depositing ground. The total amount of material removed in this way was 11,250,000 tons.

Roads, railway lines and sidings have been completed on the east side of the dock, together with a transit shed 2,000-ft. in

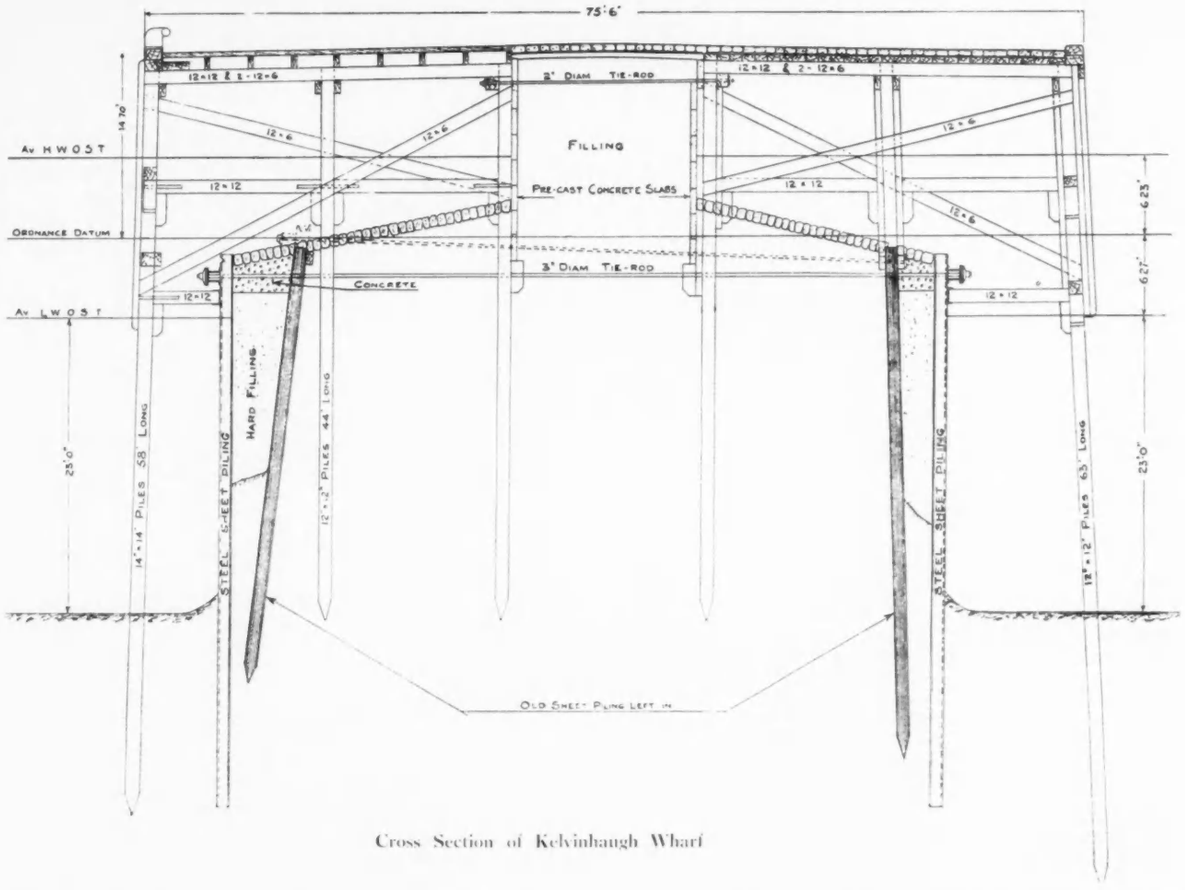


Elevation



Plan

The River Clyde and the Harbour of Glasgow—continued



Cross Section of Kelvinhaugh Wharf

length, having a clear width of 100-ft., for the handling of cargo. The whole of the quays and roadways are paved with granite, together with the floors of the transit shed, whilst the usual water, drainage and electric power services are available here, as in other docks in the port. The easy approach from the river, and the depth of water available in this dock, are such that vessels of the largest dimensions can enter or leave at any state of the tide.

Apart from the extensive reconstruction works referred to earlier in the paper, which have contributed to the modernisation of the harbour in the matter of deep-water quays, much attention has been given in recent years to those ancillary services usually referred to under the heading of equipment. Among these may be enumerated dry-docking, coaling and cranage facilities.

(To be continued).

The Melbourne Harbour Trust Commissioners

Review of Trade for the Year 1937

A review of the trade of the Port of Melbourne, Australia, represented by the gross tonnage of shipping entering and the tonnage of cargo handled during the twelve months ended 31st December, 1937, shows substantial increases over the record figure of the previous year.

The gross tonnage of shipping entering the port reached the record total of 14,438,809 tons, an increase of 487,848 tons on that of the year 1936.

The number of vessels visiting the port was 3,563, with an average gross tonnage for each vessel of 4,053 tons, compared with 3,952 tons in 1936.

The total Imports and Exports of the port again constituted a record being 6,468,202 tons which exceeded the previous record reached last year by 557,535 tons. A feature is that both imports and exports increased in even proportions on last year's figures.

The volume of Overseas Imports amounted to 1,892,323 tons as compared with 1,753,881 tons in 1936, and the volume of Overseas Exports showed a further increase from 1,006,891 tons in 1936 to 1,073,767 tons in 1937.

Net receipts for the year were £848,572 19s. 2d., an increase of £67,692 3s. 8d. on those of the year 1936.

The Revenue for the year was £850,516; Revenue Expenditure amounted to £846,723, leaving a surplus of £3,793 after providing £84,868 for the Sinking Fund which was applied in redemption of loans, and transferring £116,000 to the Depreciation, Renewals and Insurance Account. Capital Expenditure totalled £52,078, the main item in the latter being £28,944 spent on construction of modern approaches to wharves and piers.

Aberdeen Harbour South Breakwater

(COMMUNICATED)

The winter of 1936-37 was notable along the east coast of Scotland for a series of storms of exceptional violence, and the South Breakwater at Aberdeen Harbour suffered severely. This breakwater is 1,050 feet long and forms one of the principal seaworks for the protection of the harbour. Damage was sustained at various points and on 1st February, 1937, a breach was discovered in the breakwater. This was enlarged by subsequent storms, until it measured 165 feet long. It extended for the full width of the breakwater—35 feet at deck level—and the structure was damaged to a depth of 34 feet below the level of the deck, or 11 feet below low water of ordinary spring tides.

The Harbour Commissioners took immediate steps for the repair of this breach, and the work was completed in the course of last summer. A 40-ton Titan crane was purchased and a blockyard laid out at the root of the breakwater for moulding concrete blocks. The inner and outer faces of the breakwater were reconstructed by using 20-ton concrete blocks, and the heart of the breakwater was filled with mass concrete. The work, including plant, cost £37,350.

The Harbour Commissioners have just approved of additional repair work to this breakwater, consisting in the construction of a new face wall on the seaward side and a new concrete deck. The new face, which will extend for the whole length of the breakwater, will be constructed of 20-ton concrete blocks backed with mass concrete, and the new deck will consist of reinforced concrete.

The work of repairing the breach last summer was carried out in conjunction with a public works contractor; and the repairs now sanctioned, at an estimated cost of £80,000, will be carried out departmentally. It is expected that the additional repair work will take about four years to complete, as work is possible only during the summer.

Developments at the Port of Goole

Opening of the New Ocean Lock

(CONTRIBUTED)

The Ocean Lock at Goole was opened on July 2nd by Sir Josiah Stamp. It was first contemplated in 1923, when the provision of a further entrance lock to the port was considered a necessity. At that time designs for upstream and downstream locks were prepared, and the views of the local captains and pilots were obtained. The general opinion was that a downstream lock at the extreme south-east corner of the port was the most practicable, but before work could be taken in hand, it was felt that the lock could be worked more satisfactorily if the mouth of the Dutch River were diverted to the southward.

Parliamentary power having been obtained, the work was commenced in April, 1928, and completed in May, 1932, including the construction of a reinforced concrete pier which now forms a guide wall to the entrance of the lock. This portion of the work was carried out, under contract, by the Yorkshire Hennebique Contracting Company.

In 1934 tenders were obtained for the construction of the Entrance Lock proper, and the contract was let to Messrs. John Gill Contractors, Limited, of London. The work was to have been completed by August, 1936, but several difficulties arose which delayed completion.

A few facts concerning the lock and the work entailed in its construction will be of interest.

Dimensions: The lock is 375-ft. long between heel posts of inner and outer gates, and 80-ft. wide between side walls. The outer sill is 12-ft. below ordnance datum, giving a depth of 26-ft. at high water of ordinary spring tides and the inner sill 8-ft. below ordnance datum, giving a depth of 24-ft. below dock level.

Construction: To avoid trouble due to water pressure exerting an upward thrust on the underside of the lock invert, the whole site was enclosed by a line of mild steel sheet piles of Larssen type, No. 3 section, with thickened web varying in length from 40-ft. to 60-ft.

Owing to the nature of the strata on which the side walls and invert had to be founded, over 2,400 13-in. diameter and 1,100 17-in. diameter "Vibro" cast-in-situ piles spaced at 4-ft. 6-in. centres were driven, the 17-in. piles being used in the area of the gate recesses. In the vicinity of the junction of the west wall with the guide wall at the outer end, Prestcore piles were used to avoid vibration due to pile driving.

The excavation for the side walls was carried out in heavily timbered steel-piled trenches. The faces of the walls are vertical and are of mass concrete faced with brick work, built in English Bond of an average thickness of 18-in.

The 6 to 1 concrete invert was laid in alternate strips 16-ft. wide, extending the full width of the lock.

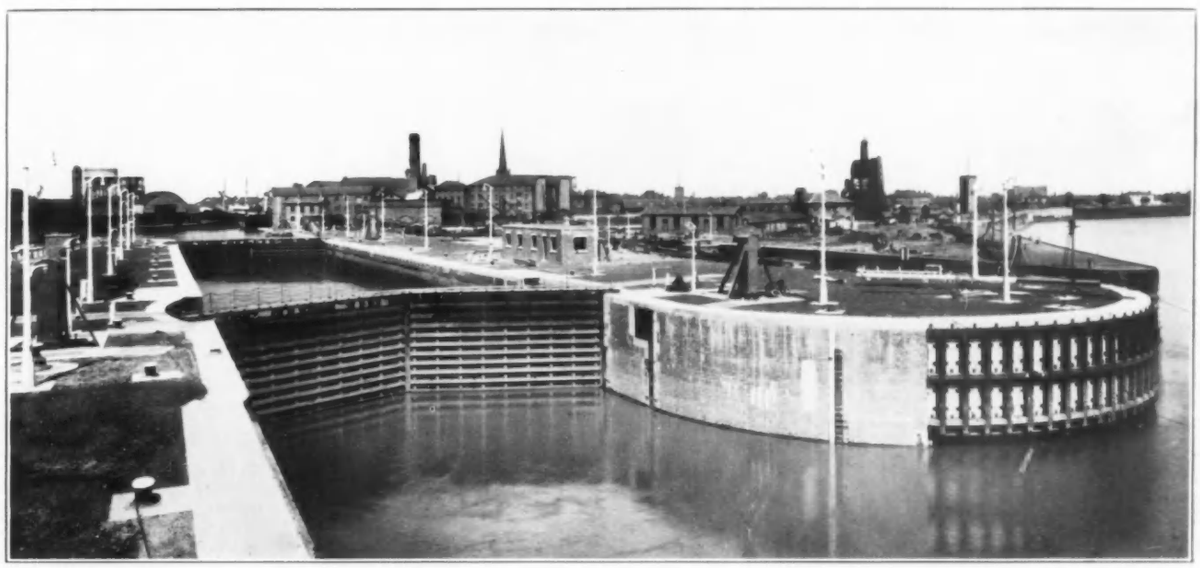
The pivot stones, hollow quoins, and sill stones for the lock gates, also the square quoins of the gate recesses and the circular coping of the forebay are of Shap granite.

Multiple levelling culverts in the inner and outer gate chamber walls were constructed for the filling and emptying of the lock. The multiple culverts merge into one main discharge culvert, and the flow of water through each culvert is controlled by a hydraulically-operated penstock, fitted in a vertical sluice shaft.

The Lock Gates are hydraulically operated, and in accordance with modern practice, are of the flotation type. They are constructed of mild steel, and the heel posts, mitre posts and clapping sills are of greenheart.

Each leaf of the inner gates weighs 102 tons in air and the outer gates 112 tons, but owing to the buoyancy of the air chambers, they weigh only 11 and 11½ tons respectively when in action. The gates can be opened or closed in 1½ minutes.

Stop grooves are provided on each side of both the inner and outer gates in the walls and across the invert, so that the gates can be isolated from the lock should this be necessary for inspection or repairs in the future.



Ocean Lock, Goole

The Outer Roundhead constructed in reinforced concrete at the south-east corner was the last section of the work to be taken in hand. A total of 192 reinforced concrete piles were driven and the superstructure consists of reinforced concrete decking, beams, radial counterforts and curtain wall.

Electric Lighting: The lock is illuminated by sodium-type electric discharge lamps. This type of lamp gives an effect which results in objects being much more clearly pronounced than with other types of lighting. Maximum visibility is obtained, dazzle is avoided, and in times of fog and heavy rain, sodium lamps have a greater penetrating power.

Signals: A Mannesmann tubular mast is erected on the outer roundhead to carry the signals for regulating vessels entering the lock from the river, whilst the signal lights at the inner end are fixed on a light standard on the North-west Pier Head for the regulation of vessels leaving the docks.

The following main quantities indicate the amount and diversity of the work undertaken:—

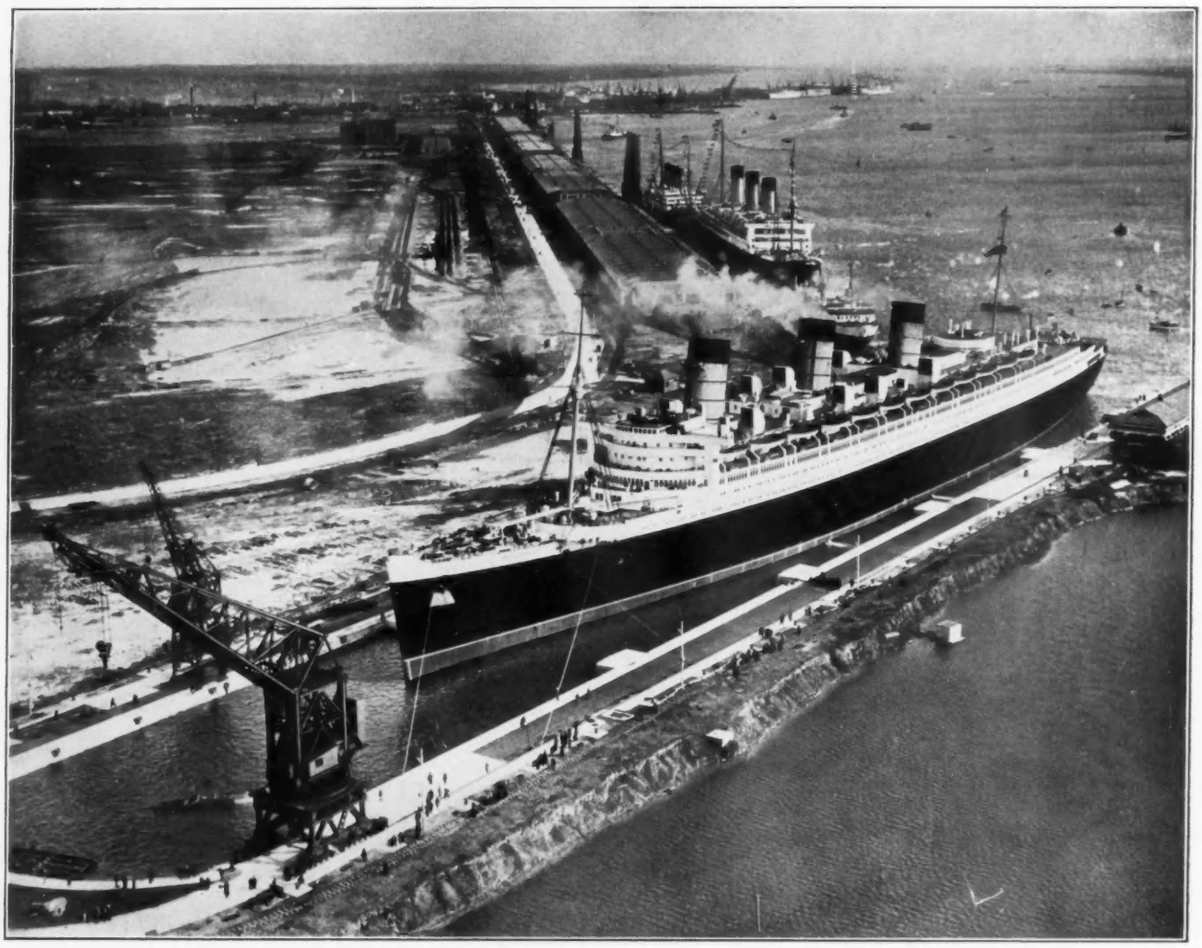
Excavation (including dredging):—	
Soft material	113,260 cu. yds.
Rock	9,031 cu. yds.
Demolition of Old Works:—	
Masonry	1,951 cu. yds.
Timber	28,548 cu. ft.
Piling:—	
Vibro piles	83,724 lineal ft.
Prestcore piles	765 lineal ft.
Reinforced concrete piles	9,061 lineal ft.
Larssen steel piles	970 tons
Concrete:—	
Mass concrete	43,582 cu. yds.
Reinforced concrete	675 cu. yds.
Brickwork	2,510 cu. yds.
Granite (dressed)	16,131 cu. ft.
Sandstone (dressed)	1,579 cu. ft.

The work was carried out under the supervision of Mr. G. R. Fenton, A.M.Inst.C.E., A.M.Inst.Struct.E., Engineer to the Aire and Calder Navigation, for whom the Consulting Engineers were Messrs. Coode, Wilson, Mitchell and Vaughan-Lee, MM.Inst.C.E., London.

Southampton Docks Extension*

By MALCOLM GORDON JOHN McHAFFIE, M.Inst.C.E.

(continued from page 261)



S.S. "Queen Mary" entering King George V Graving Dock 27th March, 1936

King George V Graving Dock

The graving dock is shown in Figs. 10, 11, 12 and 13. The dimensions are as follows:—

Length	1,200 feet
Width at entrance and between buttresses ...	135 ,,
Depth from coping to floor	59 ,,
Depth from coping to sill	56½ ,,
Water over blocks at H.W.O.S.T.	48½ ,,

The side walls have a base and top width of 30-ft. and 10-ft. respectively. They have a front batter of 4 to 1 with a toe in the form of six low-level altars. For a length of about 570-ft. along the middle of each wall a further altar is provided at level 85.50, but otherwise no altars have been provided, as, following the accepted practice of docking large ships, no side shores are used, the vessel resting on a "cradle" formed by the keel and bilge-locks. Four buttresses have been formed in each side wall to keep the bilge-keels of vessels away from the battered walls and the low-level altars; the upper portions of the buttresses are solid-fendered with English elm.

Three culverts have been formed in each side wall, one 4-ft. in diameter for floor-drainage, one for the salt-water fire main (which will be referred to later) and one in which are accommodated fresh-water mains, electric cables, etc.

The head wall is segmental on plan, and has a base and top width of 24-ft. and 8-ft. respectively. The floor is 25-ft. thick at the centre, diminishing in the form of an inverted arch to 20-ft. at the sides. The surface of the floor has a fall of 6-ins. from the centre to the two open side drains, which communicate with the 4-ft. diameter culverts in the walls. The culverts, in turn, communicate with the large filling and emptying sumps in the floor near the entrance.

Dock Construction

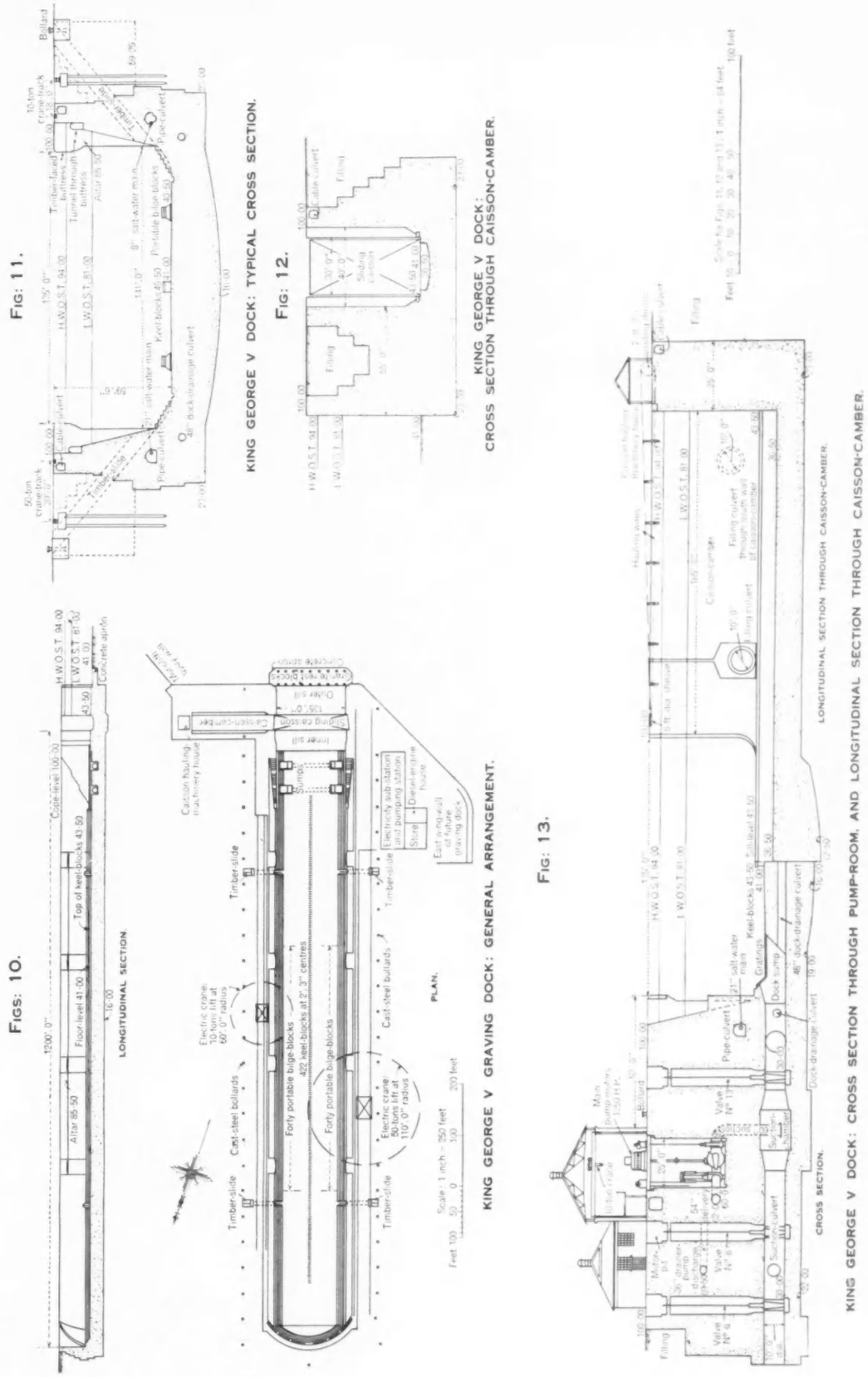
The construction of the dock was carried out in the dry. The site was bounded on the north by the original foreshore, and on the east by a previously-constructed bank, along the site of which the mud had been dredged away, the channel thus formed having been filled with firm dredged material and the bank completed with chalk cast out from railway wagons standing on a temporary timber trestle. This bank was continued in a similar construction, and concurrently another bank was commenced from the original foreshore at Millbrook Point by depositing gravel in a dredged cut by the special bank-building machine; the seaward face of the latter bank was temporarily protected by brushwood fascines, and subsequently by stone pitching. The two banks met at the east and west ends respectively of a sluice-opening 100-ft. long. The sluices consisted of steel sheet-piling, with wing-walls and sill provided for the same reason as, and in a similar manner to, those previously described, except that none of the framed timber doors were provided with openings.

The doors were dropped into position at a low-water spring tide, and chalk and gravel was cast out on either side of them as quickly as possible; simultaneously the pumping out of the enclosed area was commenced. The enclosed area was somewhat larger than was necessary for the actual construction of the dock, but it contained the gravel bed which ultimately supplied a large proportion of the concrete aggregate required for the dock; furthermore, when the gravel had been salved the enclosed area formed a valuable and convenient tipping site for the dock excavation.

In order to reduce, as far as possible, the percolation of tidal water into the enclosed area whilst the dock was under construction, a continuous wall of sheet-piling was driven along the line of the enclosing bank and the original foreshore. Trial borings along the line of this piling were made, and the lengths thereby so arranged that everywhere the piling passed through the underlying stratum of natural gravel and about 5-ft. into the sandy clay beneath. The leakage from the tide was at first considerable, but after a few days it was approximately 7,000

* Paper read before the Institution of Civil Engineers on 26th April, 1938.—Reproduced by permission of the Council of the Institution.

Southampton Docks Extension—continued

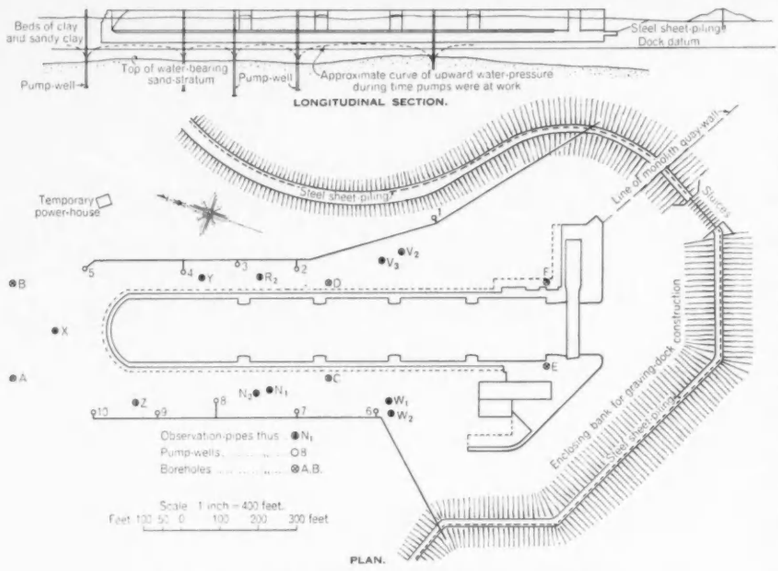

FIGS: 10.
LONGITUDINAL SECTION.
PLAN.
KING GEORGE V GRAVING DOCK: GENERAL ARRANGEMENT.
FIG: 11.
KING GEORGE V DOCK: TYPICAL CROSS SECTION.
FIG: 12.
KING GEORGE V DOCK: CROSS SECTION THROUGH CAISSON-CAMBER.
FIG: 13.
KING GEORGE V DOCK: CROSS SECTION THROUGH PUMP-ROOM, AND LONGITUDINAL SECTION THROUGH CAISSON-CAMBER.
LONGITUDINAL SECTION THROUGH CAISSON-CAMBER.
CROSS SECTION.

gallons per minute, gradually becoming less until at the end of a further 10 weeks it was approximately 1,800 gallons per minute, and remained at about this figure during the whole time the works were in progress.

Whilst the bank construction was going on a dredger was employed in removing soft mud from the area to be enclosed until such time as the gap between the advancing bank construction from the east and from the west had been reduced to a width only sufficient for the dredger to pass out. As soon as the bank was closed and pumping commenced, two steam navvies were employed to remove the mud from the remainder of the enclosed area; this mud was tipped from a jetty, specially constructed for the purpose, into hopper barges, by which it was taken to sea and dumped. The jetty was later utilised for unloading dredged gravel to supply the balance of concrete aggregate required for the dock construction.

Gravel excavation was commenced as soon as the dock area had been cleared of mud, the material being stored in a dump nearby until such time as concreting could be commenced; thereafter gravel was excavated at the rate required for the concrete mixers. Trench work was commenced as soon as possible at the entrance, so that the construction of the walls of the caisson-

Southampton Docks Extension—continued



Figs. 14. Position of Wells and Observation-Pipes

camber and the east wing-wall, together with the filling behind them, could be co-ordinated with the construction of the west end of the monolith quay-wall, and also so that the culverts and pumping station could be proceeded with as rapidly as possible. The side walls were constructed in timbered trenches, the "dumpling" between them being subsequently removed by dragline excavators. As much excavated material as practicable was tipped inside the enclosed area, the balance being tipped along the foreshore near Millbrook station.

The toes of the side walls were formed to a skewback normal to the line of thrust from the inverted arch of the floor, the latter being formed in three large voussoirs across the width of the dock. Concreting in each of the voussoirs continued uninterruptedly, including the floor surface, in order to eliminate horizontal joints. So as to maintain as much support to the toes as possible, dragline excavation of the "dumpling" was only allowed to proceed ahead sufficiently far at a time to allow shutters for the next series of voussoirs to be erected. The bottom altars were not formed at the same time as the side voussoirs owing to the complicated nature of the shuttering which would have been required, and their construction was allowed to lag behind the floor concreting to the extent of two voussoirs. The concreting of the side walls was temporarily suspended when they had reached a level of 60.00, until the floor-concrete was sufficiently far advanced. This was in order that, in the event of any tendency for the walls to settle, the thrust from the skewbacks should be transmitted to the floor-arch.

Concrete for the mass-work was mixed at a central plant situated on the former foreshore near the head of the dock. This plant combined the operations of gravel washing and concrete mixing, and was capable of an output of 2,000 cu. yds. per day. The bulk of the concrete was mixed in the proportion of 1 to 6, with a facing in the walls of 1 to 4 concrete, 12-in. thick, both mixes being placed at the same time to obviate a vertical joint.

The construction of the granite watertight faces was delayed until the concrete walls in their vicinity had been built to the full height and settlement had taken place. Large recesses were left in the concrete walls for this purpose, with numerous reinforcing rods projecting therefrom by which the concrete backing to the granite could be well bonded to the previously-constructed mass-work. Similar recesses were formed in the sills for the same purpose.

The linings for the main pumping and filling culverts were of flanged cast-iron sections bolted together. The linings were comparatively light as they had to act mainly as shutters for the mass concrete surrounding them; where the culverts joined the valve-frames they were of heavier section, designed to withstand the hydraulic pressure.

It is of particular interest to note that the Contractors were ordered to commence the work on the 1st June, 1931, and that the dock was opened by His late Majesty King George V on the 26th July, 1933, 26 months later.

Quantities

Amongst the principal quantities dealt with were:—715,000 cu. yds. of open excavation; 580,000 cu. yds. of trench and "dumpling" excavation; 460,000 cu. yds. of concrete in walls, floor, etc.; 18,000 cu. ft. of granite in sills, jambs, rubbing-courses, steps, etc.; 1,700 tons of cast iron in culvert-linings.

Artesian Water

Six trial borings, lettered A to F on Fig. 14, were put down to an average depth of −10.00 to explore the strata through which the trenches and floor excavations would have to be sunk. The order in which they were carried out was E, F, C, D, A and B, and whilst the first four disclosed the ordinary strata of the Bracklesham Beds as expected, at A and B a layer of sand containing water was encountered at a level of −3-ft., the water rising to a free level of 110.00. From this it was evident that the top of the water-bearing sand stratum sloped downwards towards the dock entrance, and further bore-holes were put down along each side of the site to explore this slope. These indicated that for about two-thirds of the length, measured from the head, there was a risk that the water-pressure would burst through the overlying beds of clay when the excavations for the walls and floor were nearing their final depths; for the remaining one-third of the length the overlying beds of clay were of sufficient thickness to overcome the water-pressure.

From the information disclosed by the bore-holes and from samples of the sand in the water-bearing stratum, a system of ten wells for lowering the water-pressure was designed by D.-Ing. Willy Sichardt; the positions of the wells are shown in Fig. 14. At each well-site a 24-in. diameter tube was sunk, and when this had penetrated a sufficient distance into the water-bearing stratum a 14-in. diameter pipe, the lower end of which for a length of about 30-ft. was perforated and wrapped with a fine copper mesh to form a filter, was lowered to the bottom. The 5-in. annular space around the 14-in. pipe was then packed with clean fine gravel in the vicinity of the filter, and with puddled clay above it, the placing of the fine gravel and puddled clay being done concurrently with the jacking out of the 24-in. diameter tube. Thus, whilst the water could gain access to the 14-in. diameter pipe, the sand was kept back by the gravel and copper-mesh filter. Each well was then equipped with an electrically-operated submersible pump, and was connected to discharge-mains which carried the pumped water outside the enclosing bank. In some of the wells more than one water-bearing stratum was encountered, separated by layers of impervious clay. In such cases a perforated filter-pipe was provided at each of the requisite levels.

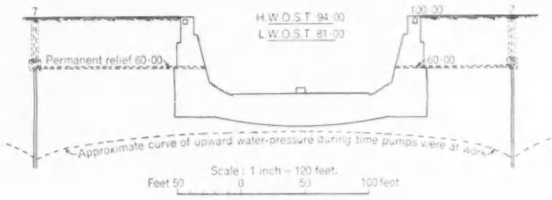


Fig. 15
Cross Section at Wells Nos. 2 and 7, showing Level of Permanent Relief of Artesian Water

For the operation of the pumps a supply of electricity was brought from the Southampton Corporation's mains to the switchboard of a temporary power-house. As it was vitally necessary to keep the pumps going continuously two diesel-engine generators (afterwards installed as part of the permanent plant at the pumping station) were provided to guard against the possibility of a breakdown in the main supply. Each of these engines was capable of generating sufficient current for all the well-pumps, and could be started up at a moment's notice.

Ten 2-in. diameter sounding-pipes were sunk to observe the effect on the water-lowering process when the pumps were in operation. These pipes were perforated and wrapped with wire gauze in a somewhat similar manner to the pipes in the wells. Fig. 15 shows the average free level of the water observed in the sounding wells during the pumping period.

When the pumps were no longer required they were stopped one by one, the cessation of pumping operations being spread over a period of about eight weeks; by this means a sudden rise in the water-level and consequent risk of cracking the fresh concrete was avoided (Fig. 16).

Careful consideration was given to the question of whether or not the water under pressure in the sand would be likely to affect the dock in any way after its construction had been completed and the pumps had been removed from the wells. Evidence gained during the excavation had shown that the clay overlying the water-bearing stratum was not everywhere homogeneous, and that in a few places it was intersected by faults

Southampton Docks Extension—continued

and sandy beds, and although these were only local there were signs that the water could creep through where they occurred and impinge on the underside of the floor. The possibility then was that the pressure might accumulate to such an extent that the weight of the walls and floor might not have been sufficient to overcome it. In view of this, horizontal pipes at level 60.00 were connected to each of the tube-wells as they were in turn put out of action, the pipes being carried through the dock-wall, thus turning the wells into permanent relief-points.

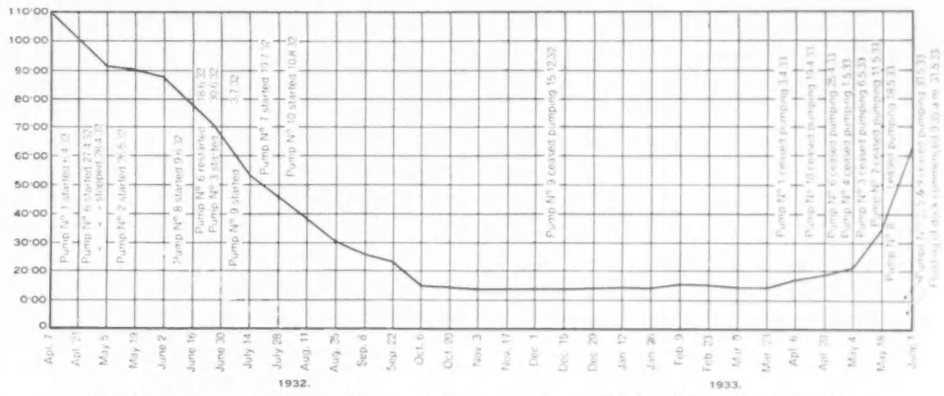


Fig. 16. Average Water-Level from Commencement to Finish of Pumping Operations

Caisson

The dock-entrance is closed by a double-faced steel sliding caisson, which is drawn back into a camber when ships are passing into or out of the dock. The caisson measures 139-ft. 9-in. long on the centre-line and is 29-ft. 6-in. wide over the timber meeting-faces. The caisson groove is provided with a watertight stop along each side, the inner stop being for use under ordinary circumstances when the dock is dry, and the outer stop when it is required to impound the water in the dock with a falling tide outside; the distance between the inner and outer stop is 30-ft., or 6-in. wider than the caisson over the timber meeting-faces. In addition, an emergency stop is provided at the extremities of the east and west wing-walls, against which the caisson is placed when it is necessary to pump out the whole length of the dock (that is, including the entrance and caisson-camber) for the purpose of examining and repairing the caisson slideways and rubbing-courses. The caisson is splayed at the ends to facilitate floating it out from the groove in which it normally operates to the emergency stop, where, when scuttled, it sits on granite rest-blocks sunk in the concrete apron.

The caisson was built and launched at the Haverton-Hill-on-Tees yard of the Furness Shipbuilding Company, Ltd. It was towed to Southampton and placed in Trafalgar graving dock (No. 6) for the finishing processes to be carried out prior to being towed into position at King George V graving dock.

The jambs and sills of the three stops are constructed of granite, and were dressed in position with patent axes in the usual manner and were finally rubbed down with carborundum; the rubbing-courses in the caisson-camber, which act as guides for the caisson, were also of granite, machine polished at the quarry, and were set accurately to the line of the finished sill-faces, no subsequent dressing being done.

Eight flights of granite steps provide access to the floor of the dock, two being at the head, one on each side of the entrance, and one alongside each of the four timber slides through the dock walls.

(To be continued).

Legal Notes

The Factories Act, 1937

(BY OUR LEGAL CORRESPONDENT)

Docks and Harbours, in common with shipbuilding and all other industrial enterprises, are closely affected by the Factories Act, 1937, which, with the exception of two sections, came into operation on the 1st July, 1938.

Sir Samuel Hoare, in a Foreword to an explanatory pamphlet* issued by the Home Office, describes the Act as an important milestone on the road to safety, health and welfare in industry. It is mainly a codifying Act, but contains numerous extensions of the former law and some entirely new provisions. Sections 42 and 71 of the Act, containing regulations relating respectively to the provision of washing facilities for workpeople and the reduction of hours of work of young persons under the age of 16, do not come into operation until the 1st July, 1939.

The Factory and Workshop Act, 1901, hitherto the principal statute governing the subject, is repealed, as also are numerous relevant sections of other enactments, and the repealed provisions are re-enacted with additions, so that the new Act forms a complete code of the present law on factories and those employed therein. The Act applies to Scotland but not to Northern Ireland.

It is expressly provided by section 159 that all existing orders, regulations, byelaws, etc., made under any of the repealed enactments, shall continue in force and have effect as though made under the new Act. New sets of regulations will presumably be made in due course by the Home Secretary, but in the meantime the Docks Regulations of 1934 are unaffected and remain in full operation.

Docks and Harbours, as such, are not "Factories" as defined by section 151 and do not come within the general scope of the Statute, but considerable portions of the Act are specifically made applicable.

The Act is divided into fourteen Parts, and comprises 160 sections and four Schedules. Its application to docks, etc., is not effected by reference to the numbers of the Sections but by descriptive reference to the various Parts. The layman may, in consequence, find it a laborious task to read the text of the Act and identify those sections which concern Docks and Harbours. Doubtless, all Port Authorities have taken legal advice and will be guided thereby, but to those officers and individuals who have to make themselves personally acquainted with their obligations, the following notes may serve as an index to the Act and enable the relevant provisions to be found with ease.

Section 105 applies numerous portions of the Act to "every dock, wharf or quay (including any warehouse belonging to the owners, trustees or conservators of the dock, wharf or quay, and any line or siding used in connection with or for the purposes of the dock, wharf or quay and not forming part of a railway or tramway) and every other warehouse (not being part of a factory) in or for the purposes of which mechanical power is used." The portions of the Act referred to in Section 105 comprise the following (the paragraphs being lettered to correspond with those in the Section):—

(a) Section 29, re-enacting and extending the law relating to steam boilers, safety devices in connection therewith and the testing and examination thereof. Also Section 32, which gives a Chief Inspector appointed under the Act power to certify exceptions from these requirements where he is satisfied that they cannot reasonably be applied.

(b) Section 38, which gives the Secretary of State power to make special regulations requiring additional safety arrangements in the case of any particular factory or class of factory where the number and nature of accidents appears to warrant it, and Section 39, giving power to a court of summary jurisdiction to make orders prohibiting the use of dangerous machinery, etc.

(c) and (d) Sections 46 and 60, giving power to the Home Secretary to make welfare regulations and special regulations for safety and health.

(e) Sections 64 to 69, requiring the notification of accidents and industrial diseases and containing provisions as to investigation thereof.

(f) Section 102, which is a new and important one, making applicable to *part* of a building which is let off as a separate factory, the provisions of Sections 1 and 5 with respect to cleanliness and lighting, and of Sections 12, 13, 22, 25 and 29 with respect to prime movers, transmission machinery, hoists and lifts, floors, passages and stairs and steam boilers. Certain

*A Guide to the Factories Act, 1937. 6d. net. H.M. Stationery Office.

of these obligations are placed upon the owner of the building, instead of upon the occupier of the part used as a factory.

(g) Sections 114-121, containing provisions as to the posting up of abstracts and notices, registers and returns of employees and other miscellaneous provisions. Section 119, a new one, lays down the duties of persons employed in factories (a) not to interfere with or misuse any appliances supplied for safety, health or welfare, (b) to make use of such appliances and (c) not to do anything likely to endanger themselves or others.

(h) Sections 122-127, relating to the appointment of Inspectors, their duties and powers, and also examining Surgeons. Also Section 128 dealing with Local Authorities and their powers and duties of inspection, and Section 129 as to the procedure for making regulations by the Secretary of State.

(i) Part XII (Sections 130-148) dealing with offences, penalties and legal proceedings.

(j) Part XIV (Sections 151-160) interpretation and general.

All the Sections referred to, except those mentioned in (c) and (f) are also applied to the processes of loading, unloading or coaling any ship in any dock, harbour or canal and to all machinery or plant used in those processes. Plant includes gangways and ladders.

In addition, the following Sections are applied to the *warehouses* defined above: Section 12, as to prime movers; Sections 13 and 14, as to transmission and other machinery; Sections 15 and 16, as to the fencing of machinery; Section 17, as to construction and sale of new machinery; Sections 20 and 21, as to women and young persons working at machinery; Sections 22, 23 and 24, as to hoists and lifts, chains, ropes and lifting tackle and cranes; Section 25, as to construction and maintenance of floors, passages and stairs; and Section 40, as to orders by a court of summary jurisdiction in respect of dangerous factories.

Finally, Section 106, which is new, will in certain circumstances affect Port Authorities. Shipbuilding yards are factories covered by the Act as a whole, but harbours and docks are not. Where, however, work is carried out *in a harbour or wet dock*, in constructing, repairing, refitting or breaking up a ship, Section 106 applies a number of provisions to that work as if the ship were a factory and the person or authority undertaking the work were the occupier of the factory. The work referred to includes scaling and cleaning boilers, combustion chambers and smoke boxes, and cleaning oil-fuel tanks and bilges.

The Sections made applicable by Section 106 are: All those mentioned in paragraphs (c), (d), (e) and (j) of Section 105, as set out above; Sections 116, 117, 119 and 120 mentioned in paragraph (g); Sections 122-124 and 129, mentioned in paragraph (h); Sections 130-138, mentioned in paragraph (i), and in addition Sections 70 to 75 (Part VI), regulating the hours of employment of women and young persons.

Deterioration of Shanghai Harbour

(COMMUNICATED)

Various reports are now arriving in this country as to the effect on the shipping facilities at the Port of Shanghai of the suspension of dredging operations which has resulted from the hostilities in progress. In addition, some alarm has been expressed as to a possible reaction of the Yellow River floods upon the physical conditions at Shanghai. As few details are available, and the fog of war obscures the view, it is not possible, or politic, to make any definite statements as to what is actually happening, or what may happen, but some indications as to general conditions may be useful to those concerned with shipping in that port.

The Whangpoo River

The River Whangpoo, on which Shanghai is situated, is a branch of the Yangtze, and is maintained principally by the tidal currents which traverse it. The bed, shores, and adjacent land consist of mud with a few sporadic patches of very fine sand. At the entrance of the Whangpoo into the Yangtze, the water of the latter river has a silt content of from 200 to 500 parts by weight per million, fluctuating with the strength of the tides and with the run-off. At a spring tide, some 3,000 or more million cubic feet of Yangtze water enters the Whangpoo River, carrying about a million cubic feet of mud. At a neap tide, both the quantity of water and its unit silt charge are smaller, bringing in perhaps 100,000 cu. ft. of mud. The average tide brings in 350,000 cu. ft. of mud or, say 250 million cu. ft. per annum, or about 13 million tons per annum or, say 10 million cu. yds. This would almost fill up the lower channel in a decade were it to remain in the river. Actually most of it goes out again with the ebb tides, aided by the run-off, but wherever the flow is checked (as in dredged hollows and embayments or on spits, shelving shores and shallow crossings) material is deposited, so that, quite apart from deepenings beyond the relatively stable depths, there is an annual accretion of one or two million cu. yds. in the lowest 20 miles or so of the river which forms the Shanghai Harbour.

The actual "in-run" of the Yangtze water is about 10 miles at spring tides and about half this at neaps, but the currents generated act in a diminishing degree for some 60 miles, picking up and dropping material. Hence silting in regions of relatively still water occurs above the actual in-run of the Yangtze water, but is reduced to quite small values above the harbour. The improvements made by training and dredging since 1906 have rendered the channel through the harbour fairly stable for a through low-water depth of, say, 25-ft., but at many places along the shores where depths greater than the régime have been maintained for berthage by dredging, accretion is naturally occurring, at a rate depending on the difference from the régime state.

Obstruction by wrecks, booms, etc., has now produced some disturbance of the régime, and will doubtless cause local scouring or silting, but it is doubtful if sufficient hindrance to the flow has been made to cause a major change. It may, however, be remarked that the removal of large wrecks in the Whangpoo is an extremely difficult task, owing to the tidal currents (up to over 3 knots), opacity of the water, accumulation of mud in the hulls and the sinking of the vessels into the river bed, where there are rapid currents, wrecks may sink in quite deeply, and it is extremely expensive and tedious to remove the parts which lie below the river bed.

Another matter which should be mentioned is the hazard which will arise in connection with dredging up unexploded shells, of which there must now be many embedded in the mud. The delays due to the necessary reconditioning of the dredging fleet must also be considered.

It is thus apparent that the natural result of the suspension of operations is a deterioration of the berthage facilities. More slowly there will develope a shallowing of the crossings. Prolonged suspension of conservancy work may lead to general accretion, and it is to the interest of all parties to see that the river work is recommenced as soon as possible.

The Yellow River

In regard to the Yellow River, it is a fact that in times past (even so recently as last century) its waters have reached the Yangtze in the neighbourhood of Chinkiang. The land from the Yellow River bed at Kaifeng-fu to Chinkiang on the Yangtze, has a drop of about 250-ft., and the catchment area of the Hwai River, which lies between the Yellow River and the Yangtze, has no definite marginal ridges across this line. The natural flow of the Hwai to the sea has long been interrupted by the Grand Canal dykes and the vagaries of the Yellow River so that when in spate much of its water now passes down the chain of lakes on the West side of the Grand Canal to the Yangtze. The Yellow River, will presumably, for the time being, usurp one or more of the tributaries of the Hwai and pass south by the same route, although it may break through to the east across the Grand Canal. Contrary to popular belief, it is very unlikely to resume its old bed, which is mostly high and has a very small capacity in spite of a canal having been recently made in it.

The silt load of the Yellow River is greater than of the Yangtze, but on the other hand, its water discharge is very much smaller. Some recent estimates put its extraordinary maximum up to 1,000,000 cu. ft. per second, which is the approximate value of the mean discharge of the Yangtze. Previous estimates were only half as much, and it is probable that the usual summer flow is less than 20 per cent. of the usual summer flow of the Yangtze. This would not all reach the Yangtze, but perhaps half might do so, and together with the run-off from the Hwai would be an unwelcome addition, which, with over high stages in the Yangtze, would aggravate flood conditions at Chinkiang. Owing to the immense tidal volume in the estuary and the proximity to the open sea, it is, however, not likely to raise the water level at Shanghai by more than 1-ft. As to the silt of the Yellow River, in the absence of new dykes most of this will remain behind on the flood plain, so that it is probable that the Yellow River will have been again brought under control before its silt reaches the Yangtze in sufficient quantities to do important damage in the estuary of that river. The Yellow River silt is mostly loess, even finer than the bar material of the Yangtze, and the powerful tidal currents in the estuary of the Yangtze will have no difficulty in carrying it out to sea.

If the conditions were to be prolonged for decades, a more pessimistic view would be warranted, but the local effects of a Yellow River break in northern Honan, northern Anhwei and northern Kiangsu are so extremely serious that for that reason alone, steps will almost certainly be soon taken to control the river, irrespective of its effect on the Yangtze. In the winter its flow is very small, and with the immense labour resources and great necessity to protect the arable areas, the reversion of the river to a (temporarily!) controlled channel cannot be long postponed.

Notes of the Month

Port of Dublin Appointments.

Following the recent confirmation of the appointment of Mr. R. F. Lowe as Secretary to the Dublin Port and Docks Board, Mr. J. P. Flynn has been appointed Accountant; Mr. T. S. Rooke, Collector of Port Dues; and Mr. J. P. Murphy, Assistant Secretary.

Reduction of Shipping Dues at Sulina.

The European Commission of the Danube have modified the navigation dues to be paid by vessels operating in Sulina Harbour between December 15th, 1938, and March 15th, 1939, on a tariff which represents a reduction of one gold franc per E.C.D. register ton on the combined operation of transhipping grain from Danube lighter into steamer in Sulina Harbour.

Bombay Port Trust Finances.

At a recent meeting of the Bombay Port Trust, the Chairman informed the Board that the Accounts for the year ended 31st March, 1938, had been closed, and showed a surplus of Rs.23.68 lakhs, including Rs.10,000 under the Pilotage Account. Revenue amounted to nearly Rs.8 lakhs more than that of the preceding year, while Expenditure was less by over Rs.1 lakh.

Retirement of Port Official.

On July 1st, Colonel T. H. Hawkins, C.M.G., Assistant General Manager, retired from the service of the Mersey Docks and Harbour Board. He had been Assistant to the General Manager since 1919, and had specialised particularly in rates and dues and master porterage. Col. Hawkins' services were eulogised at the meeting of the Board just prior to his leaving, and appropriate good wishes were extended to him on his retirement.

Southampton Dock Imports.

The 1937/1938 South African deciduous fruit season which has just closed is reported to have been highly successful, and the Port of Southampton, which receives practically the whole of the Union's exports of this produce to the United Kingdom, has dealt with more than 4,300,000 packages, a total comparable with the record shipments of the 1935/1936 season. Some heavy seasonal shipments of Australian and New Zealand produce have also been handled at the docks this year.

Beirut Harbour Extension Works.

The extension works recently in progress at the harbour of Beirut, Syria, have now been completed, and a portion of the new accommodation is available for use. The North breakwater has been lengthened by 491.56 metres, and 427 metres of quayage have been provided for the mooring of ships with a depth alongside of 11½ metres at low tide. At the northern extremity of the Mole there is another quay of 138 metres in length, while a third, just over 200 metres, is at the eastern end of the North quay; both of these have a depth alongside of 7½ metres at low tide.

New Channel Entrance at Geelong.

A new channel leading into Corio Bay, Victoria, has been put into commission by the Geelong Harbour Trust. The dredging of the channel, begun in 1933, has been completed at a cost of £106,000. The port can now be used by merchant ships without the necessity of discharging part cargo at Williamstown, because of the limited draught hitherto prevailing. It is anticipated that Geelong will become the main wheat export centre for the State of Victoria, and the Harbour Commissioners are now engaged in dredging the Hopetoun Channel so as to widen it from 220-ft. to a navigable width of 300-ft., in conformity with the New Cut.

New Deep Sea Dredging Appliance.

It is reported that a demonstration of a deep-sea dredger, based on a new principle, has recently been carried out at Monterey Bay, California, U.S.A., in the presence of two representatives of the United States Government. The following particulars are extracted from "Port and Terminal" of June 25th. "The seven-ton two-yard clam shell (anglicé-grab) worked at 115 fathoms. It operates on a principle whereby the dead weight of water at a great depth is converted into mechanical energy. When the bucket drops on the sea bottom, a system of valve locks is tripped, and water floods a series of large cylinders, forcing down heavy pistons. The pistons are coupled to the clam shell which then "bites" under this driving force, after which the loaded bucket is hoisted by an ordinary steam winch. The closely-guarded secret of the inventor (Mr. John C. Williams, of San Francisco) lies in the heavy grease type packing round the piston heads, which eliminates a high percentage of pressure leaks."

Traffic on St. Lawrence Canals.

The annual report for the year 1937 shows a total of 9,195,439 tons of freight traffic on the St. Lawrence Canals for the year. This is 11 per cent. in advance of the return for 1936, and is also in advance of the previous high record set up in 1928.

Air Raid Precautions in the Port of London.

The Port of London Authority announce that they have appointed Rear-Admiral R. W. Oldham, O.B.E., to be their Air Raids Precautions Officer. Admiral Oldham retired from the Navy at the beginning of this year, and subsequently assumed duties in the A.R.P. Department of the Home Office.

Clyde Navigation Trust Revenue.

The Chairman of the Clyde Navigation Trust (Mr. W. F. Robertson) was able to announce at the last monthly meeting of the Trust, that the annual revenue had exceeded one million pounds for the first time since 1930. The accounts for the year to the end of June showed increased receipts in all departments, except the granary and the lairages.

Aberdeen Harbour Development.

The Aberdeen Harbour Commissioners have approved of a scheme for reconstructing the east face of Matthews' quay. The wharf, which is 255 feet long, will be reconstructed to permit of the berth adjacent to it being dredged to a depth of 26 feet at low water. This will enable vessels to approach and leave the wharf at all states of the tide. The estimated cost of the work is £19,000.

Port Improvement at Loanda.

It is announced from Lisbon that the Portuguese Government propose to expend one million pounds on public works in their Colony of Angola on the West Coast of Africa, including the modernising of the Port of Loanda, which is the capital of the Colony. Loanda, or more properly St. Paul de Loanda, possesses a very fine natural harbour, the entrance to which has been allowed to deteriorate through the absence of dredging operations. Notwithstanding this drawback, the port does a fairly extensive trade. The President of the Portuguese Republic, General Carmona, has gone on a visit to the Colony.

Maritime Works Acts.

The following works have received Parliamentary sanction in confirmation of Provisional Orders previously made earlier in the year. At Plymouth the Corporation, in conjunction with the County Council of Cornwall, are promoting the construction of a floating landing stage, about 50-ft. in length and about 25-ft. in breadth in the harbour of Hamoaze, together with a connecting bridge and quay with an approach road. At Clacton-on-Sea the Clacton Pier Company, Ltd., are engaged in extending the existing pier by a width of about 128-ft., and sanction is given for the installation thereon of switchback railways and circular rides.

Mersey Docks Shipping Traffic.

A comparative statement just issued on the year's working of the Port of Liverpool shows that the total tonnage of vessels using the docks for the year ended 1st July, 1938, amounted to 16,530,693 tons, which constitutes a record, being greater than last year by 407,000 tons and 350,000 tons greater than the previous record year of 1930. Lt.-Col. Buckley, at a meeting of the Mersey Docks and Harbour Board on July 7th, in mentioning this, added that there was a falling-off in outward Dock Rates and Town Dues on goods, which was disappointing, but not unexpected, in view of the international position. He was, however, able to say that the total revenue on ships and goods shows an increase over last year of £4,955, despite the reduction in Dock Tonnage and Wharf Rates on vessels as from July 2nd, 1937, of 10 per cent. in lieu of the 7½ per cent. formerly allowed in these rates. The effect of this reduction for the year was approximately £39,000.

Proposed Deepening of Baltic Channel.

Representations have been made to the Swedish Government by three Swedish maritime bodies—the General Shipping Association, the Swedish Shipowners' Association and the Harbour Authorities Association—in regard to the necessity for deepening the Flintrännen Channel, the entrance to the Baltic on the Swedish side of the Sound. By reason of variations in water level, the usual available depth in the channel is less than 6.5 metres, whereas last year 122 Swedish vessels had a loaded draught in excess of this figure, and could not have passed through without discharging part of their cargo. The Danish channel, Drogden, was deepened to 8 metres in 1925, but even this is found insufficient for a number of vessels, which must either use the Great Belt or the Kiel Canal.

Echo Sounding in Harbour Hydrography

By Lieut.-Commdr. D. H. MACMILLAN, R.N.R. (Retd.), Extra-Master Mariner, A.I.N.A.

FOR a century, at least, the seaman-surveyor has anxiously searched amongst the unfolding principles of increasing scientific discovery for some method of vertical submarine measurement, which would solve for ever that small margin of doubt which has always surrounded the ancient use of lead and line.

The present century has seen so remarkable an increase in the maximum draught of steamships, that the Port Surveyor must now determine the greater depths with the same meticulous precision as has been demanded of him for the lesser in times past.

In approaching soundings from seaward, the need for close detail and precision was once determined by the five-fathom contour, but modern progress in Naval Architecture, taken together with the " squat " of large vessels in shoal depths at critical speeds, has increased the range for detail to at least seven fathoms below M.L.W.S. Data.

It is the writer's contention that real precision at such a depth is not attainable by ordinary " lead and line " methods, for the following reasons:—

(a) The catenary of the lead-line, due to differential current layers, always causes the " calling " of excessive depths, despite the appearance to the leadsman and surveyor of a " plumb " cast. Surveys over identical sections at different states of tide have frequently given perplexing differences in proof of this, and it is, of course, an axiom amongst seamen that over-estimation of depth is fatal.

(b) The settling of the lead into soft mud and clay. This also gives an excessive depth. The contention that what is not " felt " by the lead cannot obstruct a ship, is a serious fallacy. A heavy-draught vessel requires every inch of bottom clearance at Ordinary Spring and extreme Low Water times, in order that her screw " feed " current may be as ample as possible. Her " squat " is thus reduced, and her general handiness under helm and engines increased.

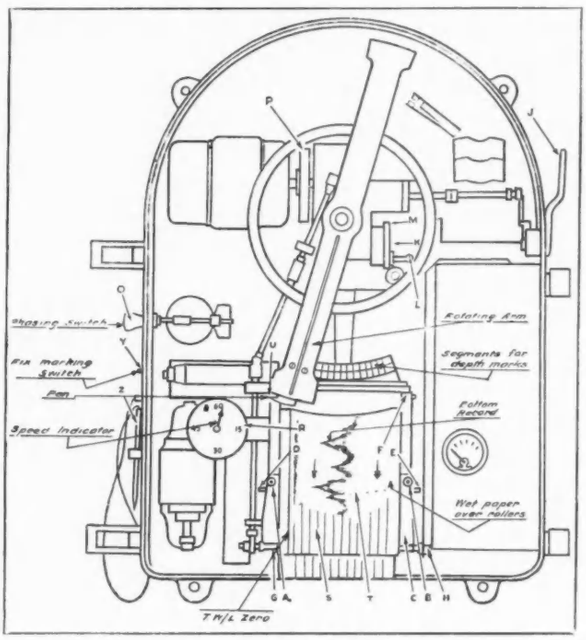


Fig. 1

(c) The tension due to the usual leads (10 to 20 lbs.) is not great enough to ensure that the best type of lead-line (with Kelvin wire heart) is representing depths to the same degree of accuracy as when it is horizontally stretched and " taped " before and after using.

(c) The speed of the sounding boat must be quite low for the best lead work, and whilst giving all due credit to the splendid performances of first-class leadsmen, it should be remembered that the necessarily short instant of " plumbing " and " feeling " at a depth of over five fathoms from a vessel, under way, lacks that deliberation necessary for the critical accuracy which such a measurement surely demands.

When causes (a), (b) and (c) are acting in concert, it is clear that discrepancies between the Navigator and Surveyor are by no means surprising, unless the latter has been wise enough to reduce his soundings by the " full foot " method of tidal reduction, and/or reject inches in his reduced depths. If, however, he is too cautious he will be censured for unnecessarily restricting shipping—a good but irritating fault!

Fortunately, the dream of the old Surveyor-Captains and Admirals has been realised and a panacea for the ills of lead sounding at last discovered.

The Magneto-Striction Radial Arm type of Echo Sounding device has solved the problem by enabling the Surveyor to take ashore a paper record giving a continuous profile of the bottom section which his sounding boat has traversed, to a definite accuracy of within 3 inches, punctuated with " fix " lines indicating the points where his instantaneous double angles for position were taken.

These consecutive numberings agree with the plotted points of the boat's track marked upon the plotting graph of position (see 7a).

The interesting point about such a record—or Echo-roll—is that it bears internal evidence of its true Zero of soundings after the " bar-check" has been carried out at definite depths.

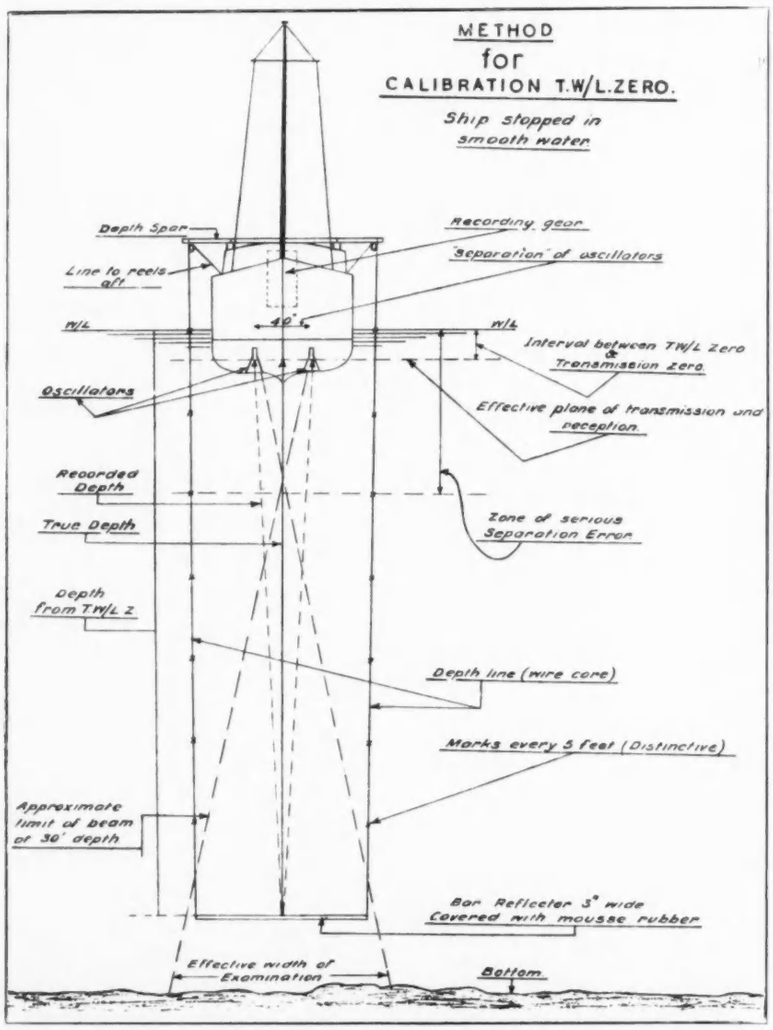


Fig. 2

Echo Sounding in Harbour Hydrography—continued

The section is not only a continuous and accurate record of Electro-sonic soundings taken at the rate of 300 p.m. (i.e., one every 2-ft. at 6 knots), but in addition, represents a track which is not just a line, but a *strip* or *band* of "examined" area, equal in width to about one-third the depth—as the effective "cone" of sonic sensitivity is about 15° from the vertical.

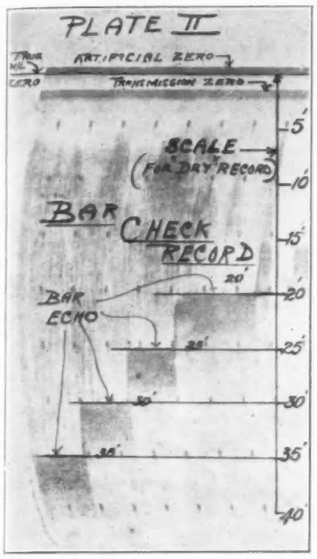


Fig. 3

Thus any pinnacle or obstruction within this zone would show a "side" echo or "shadow," and so indicate the need for a further and closer examination.

It is not the writer's intention to describe in detail the technical parts and principles of the instrument, but rather to outline its practical application to the Harbour Surveyor's requirements.

The instrument graphically measures sound intervals by respectively recording the points of transmission and reception upon specially treated starch-iodine paper moving over rollers at a constant speed, which allows time intervals to be automatically recorded. (See Fig. 1).

The depth interval is therefore represented by the linear interval between the recorded point of transmission and reception—denoted respectively by the brown chemical precipitation marks—the scale calibration depending upon a standard rate of sound in water—4,800-ft. per second.

This is mechanically achieved by a rotating arm bearing a "pen" of carefully regulated spring pressure which traverses and contacts the moist paper at a standard speed of 300 r.p.m., which speed is a function of the scale calibration. (See Fig. 1).

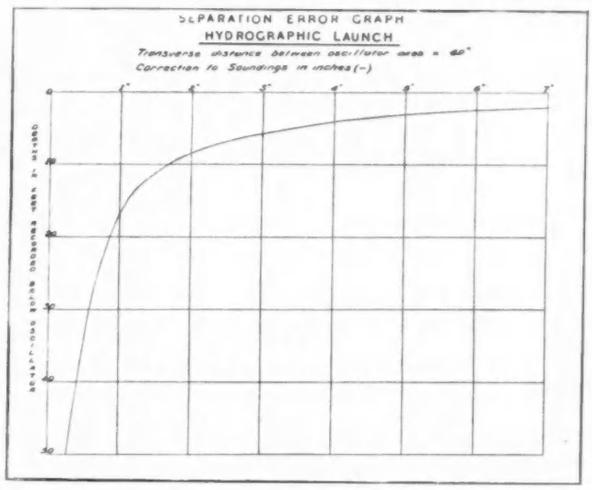


Fig. 4

Continuous recording by the instrument gives such a close succession of these markings, as to show in practice a *line* of transmission, and a *line* of depth.

By pressing a button at the instant of fixing the position of the Survey Launch, a continuous line is "drawn" upon the record, and an "electric contact" pen enables the numbering of the successive "fixes" to be made without interrupting the record. (Fig. 1).

It should be noted that the scales used for measuring depths upon the record are in sine relationship to the arc traversed by the "pen."

The paper record has, of course, to be dried before plotting can be carried out, and this is accompanied by a certain amount of transverse shrinkage which affects the final scale upon which soundings are read. Fortunately, with the use of standard paper, the co-efficient of shrinkage is very constant and is allowed for in the graduation of the metal scale provided with the instrument.

In addition, as the instrument automatically marks the depths from 0–40-ft. at 5-ft. intervals upon the direct scale (i.e., on the wet paper) the dry scale can be checked for accuracy and consistency very easily. When this test is satisfied, the results can be confidently relied upon.

The scales of the instrument used by the writer are approximately 8-ft. and 16-ft. to the recorded inch, each capable by a phasing arrangement of recording a depth range of 75% more than the single traverse of the paper width would permit (i.e., 40 and 80-ft. respectively).

As the scale (8-ft. = 1-in.) is that affording a precision of 3-in. of depth in practice, this scale will be that particularly described and illustrated in this article.

The writer accepted the M.S.X. instrument (as illustrated) upon the essential condition that an accuracy of depth within 3-in. was to be given in practice.

The tests were to be made in dry dock at high-water level, and depths compared with the readings of the inner gauge (top of block zero) and also the sill level. The instrument came through with first-class honours, showing a perfect agreement between the record and dock gauge. In addition to the tops of the blocks, the dock bottom was shown; with launch moving slowly across the dock, the camber of the bottom was also clearly discernible.

Salinity and temperature affect the speed of sound in water, but within the ranges used by the Harbour Surveyor the variations are infinitesimal, and can be checked by the "bar" method described below. (See Fig. 2).

Speed error is directly proportional to "standard" speed, the performance of which can be checked by comparing a specially calibrated pointer borne upon the instrument with a good stop-watch. (Fig. 1).

In practice the writer has devised an "absolute" check upon the instrument, which avoids the necessity of applying increments due to speed variations. A 3-in. width angle bar, weighted at the ends and totalling 70 lbs. in weight, is slung from calibrated lines rove through yard-arm blocks from a spar borne in crutches and clamps athwart the boat directly above the oscillators. The lines are hemp lead-line (cable-laid) stuff ($1\frac{1}{4}$-in. circ.) into which a Kelvin-wire "heart" has been worked. With boat stopped in smooth water, the bar is hooked on by self-mousing hooks to the port and starboard depth lines, and launched over the stern.

The depth lines are then reeled out until the required marks say 35-ft.—are *on the waterline*, on each side of the boat. As these lines are continually checked as a routine by steel tape, the top of the bar is thus at the required depth, the weight of 70 lbs. overcoming differential current effects. The Echo machine is then switched on and the bar "echo" recorded.

As the sea bottom is *also* recorded, if this is hard, the line will be found to slack as soon as the bar is lowered to a position where "Bar" and "Bottom" records are in coincidence. If the bottom is soft the difference in level between the "bottom" on the record and the depth of line at the moment of "slacking" will indicate the softness of the bottom, and the penetration of the bar. It will thus be seen that the "bar-check" constitutes the criterion for the true waterline zero (T.W/L.Z) of the record bearing it. (See Fig. 3).

Whilst the old surveyor measured his lead-line after sounding, the Echo surveyor will carry out a "bar-check" every time he uses the instrument and watch his instrument by stop-watch throughout its use.

A further small correction known as "seperation error" will now be considered in conjunction with a brief outline of some of the features of installation. This correction (which is subtractive) is due to the horizontal distance between the transmitting and receiving oscillators. (See Fig. 4). The recorded depth is thus greater than the true by an amount which decreases inversely as the depth of water.

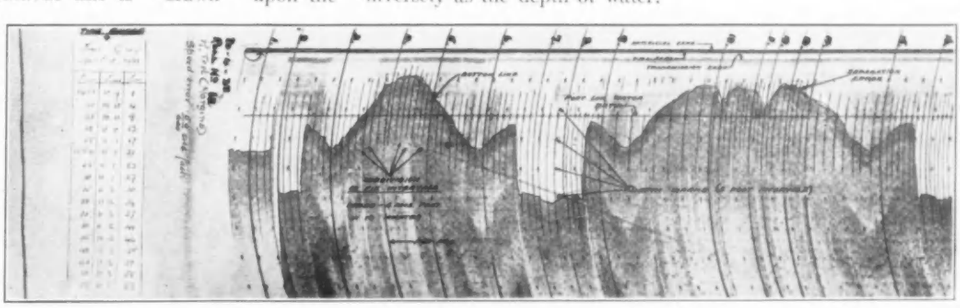


Fig. 5

Echo Sounding in Harbour Hydrography—continued

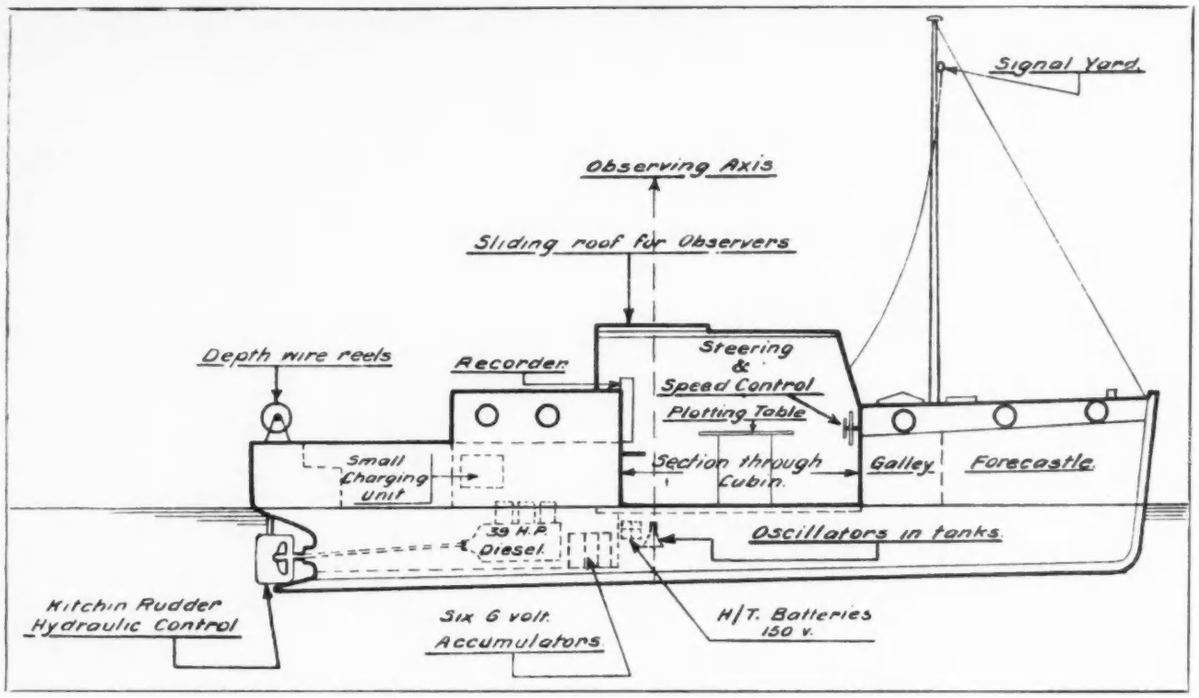


Fig. 6. Profile Sketch Survey Launch

The value of this correction is determined by the formula $c = D - \sqrt{(D^2 - (\frac{S}{2})^2)}$ where C = the subtractive correction to recorded depth D.

D = Recorded depth.

S = Horizontal distance between vertical axes of the oscillators.

For example, if the oscillators are 40-ins. apart, the recorded depth is 7½-in. in excess of the true, at a depth of 2-ft. (below the oscillators); 3½-in. at a depth of 5-ft., and only 1½-in. at a depth of 10-ft.

In such a case, it will be sufficient, as a safe principle in practice, to pencil in the recorded "bottom" 3-in. above its "surface" when the depth is between 2-ft. and 5-ft. (See Fig. 5).

Let us examine some of the points to be considered in installing a sounding set (M.S.X.) in a small Diesel-driven launch, such as that used by the writer. (See Fig. 6).

The dimensions of the vessel were: length 35-ft., breadth 9-ft., and draughts: forward 2-ft. 6-in., aft 3-ft. 6-in. Speed 8 knots.

It was decided to fit the oscillators abreast each other and 40-in. apart on either side of the keel, at a position over which all observed angles for location were to be taken.

This position was also about the L.C.F.*, in order that small changes of trim, under way, would not effect recorded depths.

The effect of moderate rolling is counteracted by the fan-shaped beam sent out by the transmitting oscillator, which is disposed approximately 15° about the vertical axis of transmission. (See Fig. 2). In shoal depths this angle is increased.

The exact vertical distance of the "effective" base of the oscillators above the keel was then taken by level on the stocks, in order that the vertical distance between waterline and "plane

* Longitudinal Centre of Flotation.

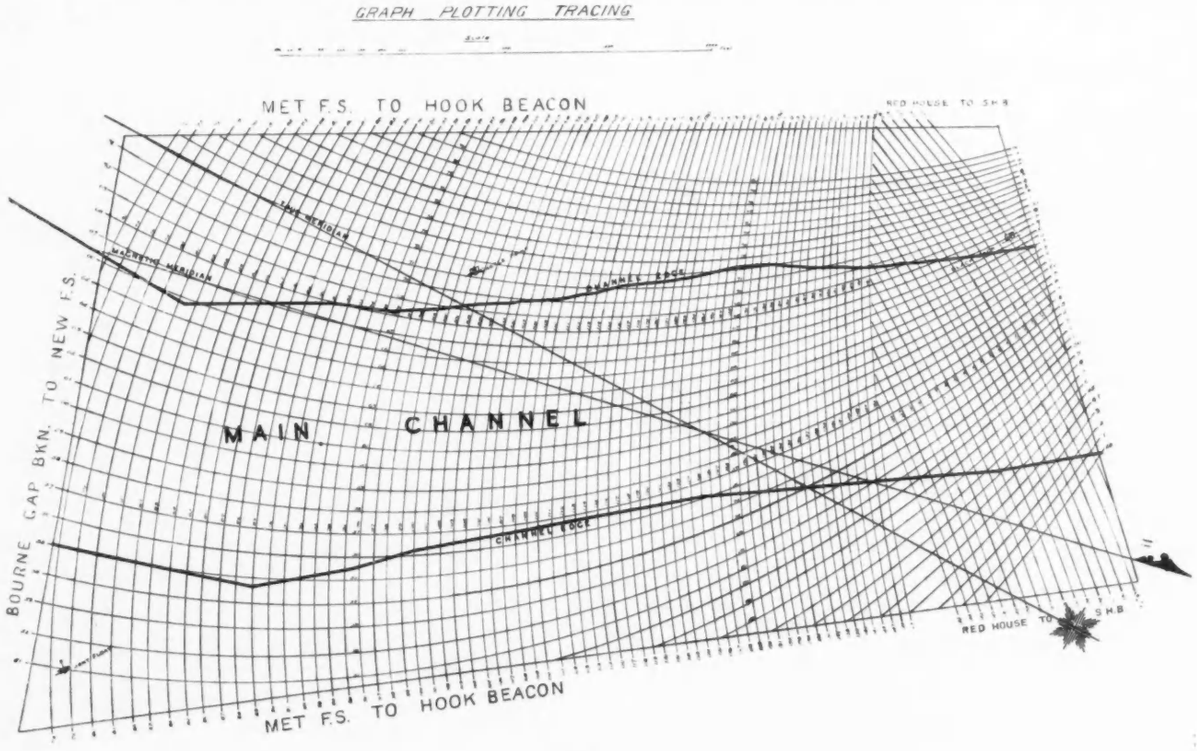


Fig. 7

Echo Sounding in Harbour Hydrography—continued

of transmission " could at any time be computed from mean draught and applied above the " zero of transmission " as a check upon " waterline zero "—in conjunction with any speed variations noted by stop-watch.

As the craft was a wooden one, holes had to be cut for the oscillators and compensation made. This is not necessary in steel vessels.

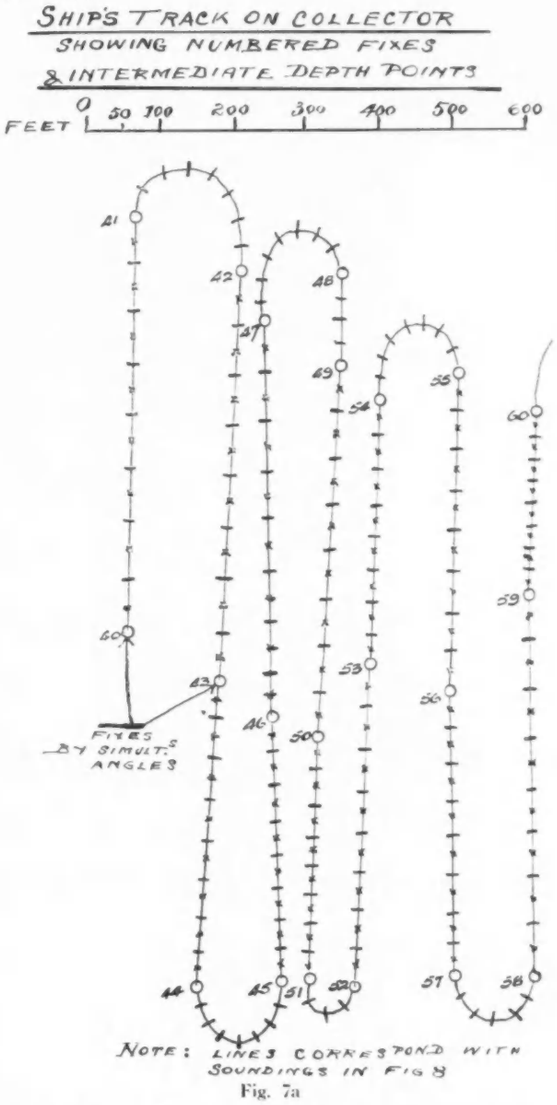

SHIP'S TRACK ON COLLECTOR
SHOWING NUMBERED FIXES
& INTERMEDIATE DEPTH POINTS
FEET 0 50 100 200 300 400 500 600
FIXES BY SIMULT: ANGLES
NOTE: LINES CORRESPOND WITH SOUNDINGS IN FIG 8

Fig. 7a

In the writer's view, a good shallow draught and beamy launch, of from 35-ft. to 45-ft. in length, is the most suitable for harbour survey work, for the following reasons:—

(1) " Squat " in shallow water is least felt, and thus one correction is eliminated.
(2) Variations in fuel and F.W. disposition and quantity have less effect on mean draught than is the case when the unit is fitted in large tenders.
(3) Rigging and handling of gear for " bar-check " is easy, on account of light draught and relatively small beam, and thus constant checks are simply carried out.
(4) " Separation " error is kept small.
(5) Sextant observers can observe precisely over the set of oscillators when under way.
(6) With " Kitchin Rudder " control " manœuvreability " is almost infinite.

With reference to this latter feature, the writer has found such hydraulic speed control of great value in Echo work, because speed can be adjusted to get best records with an infinite gradation to wind and sea conditions, quite unattainable by any other means.

A launch fitted as above becomes a survey instrument of mobility and accuracy, the " fixes " observed directly locating the exact positions of the soundings, which can be plotted directly upon a large-scale working sheet without those corrections for " distance from Observer to lead," which in many cases drive the surveyor to a pulling boat for large-scale detail work.

An interesting point about such Echo work, is that when " wash " from passing vessels, a rough sea, or swell, causes " aeration " around the oscillators, the " bottom " record ceases for the time being until normal conditions are resumed. This is an automatic veto upon:—

(1) Sounding in narrow channels at times when shore tide gauge readings may not represent true levels where ships are passing.
(2) Sounding under weather conditions which are not conducive to good work.

It is most important to arrange a sound working drill in the Survey unit above described.

When on " Survey Stations " the following routine is advantageous:—

(a) The two Surveyors take up a position to observe angles overall immediately above the oscillator position, and prepare to plot the sounding course.
(b) One seaman is stationed to keep a look-out and act as " fix-marker " by pressing an electric switch button when the Senior Surveyor calls " stop " at the instant of fixing position.
(c) The sounding operator prepares the machine for recording, switches on when ordered, and keeps a watch on the record throughout the survey—checking and numbering the successive fixes which must correspond with the record kept by the Junior Surveyor in the " sounding book."

It is advisable that one seaman should specialise in operating and tending the machine throughout all survey work, as innumerable small annoyances (cutting of paper, etc.) are thus anticipated and avoided.

As the speed of the instrument is standard at 300 r.p.m. for the radial arm carrying the pen, the sounding operator must frequently check the speed error over 10-minute intervals.

The variation in seconds for a 10-minute " run " gives the depth error in inches at 50-ft., e.g., 3 secs. fast = 3-in. too deep.

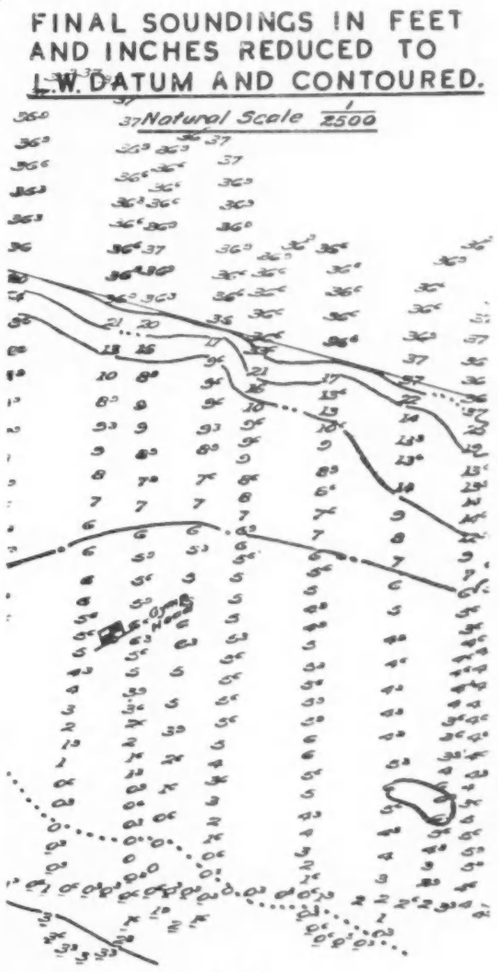


Fig. 8

The writer has rarely known this to change more than one second in a two or three-hour survey, and thus the " bar-check " described above gives a definite criterion for the true " waterline zero " which embraces all corrections.

As in other hydrographic work, all basic standards are checked as a routine. Depth wires are checked weekly by steel tape, stop-watches are timed monthly by chronometer, "phase" and primary zeros are kept in true adjustment, and the necessary spares (valves, pens, etc.) kept handy on board, in order

Echo Sounding in Harbour Hydrography—continued

to save delay in the case of minor breakdowns away from "home base."

The advantage over lead methods of a carefully-spaced pattern of survey lines, run continuously, over a given area at 5 to 6 knots, together with a precise and continuous depth record punctuated by "fix markings," is too obvious to need dwelling upon.

It may be interesting to mention a further benefit.

Normally the Surveyor takes advantage of prominent natural objects in the spacing of his sounding lines for covering a given area.

The only other solution, is to steer compass courses whilst surveying, but unfortunately, if the lead is used, steerage way is necessarily so small, and wind and tide have so relatively great an effect, that such courses would be difficult to maintain in all but good-sized tenders.

The speed at which one can survey by Echo methods overcomes this difficulty, and the writer can steer courses upon an adjusted compass, in the craft mentioned above, with all necessary precision.

The magnetic effect of the Echo gear is quite small and easily compensated in practice.

A word about methods of plotting to accommodate the higher speeds of survey.

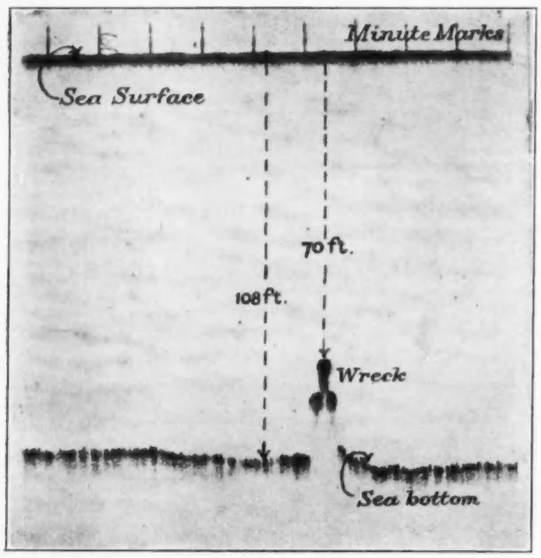


Fig. 9

Apart from small dock wall surveys, run on transits (objects in line) using the hand lead, and wire-measured distances, the best, and even only seamanlike method of plotting the position of a survey vessel under way is by means of two simultaneous horizontal sextant angles taken upon correctly triangulated, and suitably disposed, conspicuous and fixed objects.

The "three point fix," as it is called, enables the Surveyor who is plotting to set the angles upon an instrument known as a Station Pointer, and by its means locate the point upon the "working sheet" laid out upon a plotting table carried on board.

As this routine of reading the sextant, setting the station pointer, and then using it on the plotted trig. points, takes from 20 to 40 seconds (and certainly the latter if one is as careful as one should be), it is clear that during this time, the launch has traversed from 200 to 400-ft. at 6 knots.

By this time, it is necessary to fix again if one wants a detailed course. Under such circumstances the Surveyor is not sufficiently free to "conn the ship," study his contours, or check his course, unless he reduces speed—which action would, of course, annul the advantages of Echo work.

The answer to this dilemma is to be found in producing a "working sheet" bearing arcs of position so plotted that they can be used as co-ordinates, of position. (See Fig. 7).

The objects should be chosen that the resulting arcs at the required area intersect as nearly at right angles to each other as possible, and, of course, vary in radius as sensitively as desired.

This process is a new hydrographic technique in itself, and the writer has no space to deal with it here, but let it suffice to say that by its means the position of a launch, under way, can be plotted accurately within 5 seconds of the time of observing the simultaneous angles for position.

The setting of the station pointer, and the adjustment of it to the "points," are thus eliminated; high survey speed can be maintained together with fixes at close linear intervals, and easy supervision is possible throughout.

We now come to the drawing office side of the work.

Fig. 5 shows an Echo record ready for plotting, and the following points in preparing it must be attended to:—

(a) The true "waterline zero" must be drawn in throughout as deduced from the "bar-check" data contained in the record.

(b) A slip relating the fix markings to the times of gauge readings (every 5 minutes) is prepared and pasted on the record.

(c) The tide gauge readings are then plotted as requisite below the true "W/L zero" at short intervals, and a line joining them all drawn in. This is, of course, the actual Port Low Water Datum of soundings, and it will be seen that the reduced soundings are directly measured from this line.

The usual lengthy arithmetical process of reduction is thus eliminated, and yet another source of error removed.

(d) The next stage is the division of the intervals between the fix markings into a convenient number (say eight) of equidistant longitudinal intervals.

This is done by so dividing the Datum line and then transferring the points to the "bottom" record in a roller frame, which takes into account the arc traversed by the pen on the radial arm.

(e) Standard annotations for reference are finally made upon the record detailing speed variations, consequent depth error, filing number, area sounded, sounding book referred to and dating. The record is now ready for plotting, and providing this organisation is standard and the office staff are skilled, it takes a very short time.

The preparation for final plotting upon a tracing has meanwhile been proceeding, as follows:—

(a) The "working sheet"—usually a plotting graph—is examined to check fixes and consecutive numberings.

(b) A "collector" tracing with "points" and essential details—from a metallic standard sheet—is then placed over and in relation to the working sheet graph, and the survey course and fix points transferred with numberings. This automatically compares working sheet or graph with the standard on metal, and paper distortion is incidently checked.

(c) The intervals between fixes are then sub-divided as above to correspond with the Echo record sub-division. (See Fig. 7a).

As Echo record and collector tracing are now ready, all that remains to be done is to read directly the reduced soundings by scale from the Echo record and inscribe them upon the tracing at their appropriate positions, interpolating any greater detail that may be required.

As a check line can be run across the pattern of soundings during the survey, a complete check upon consistency is thereby given.

The result is then contoured, and further examination made afloat wherever the contours appear to be incomplete or bottom features and tendencies suspicuous. (See Fig. 8).

Again the value of a sounding beam or "cone" giving a "lane" of closely-examined area, as against a series of points sounded by a lead, is very great indeed.

The labour and cost of identifying pinnacles or submerged piles in the past is by this means eliminated so long as sounding lines are so spaced as to arrange for "bottom areas" to overlap each other.

The writer has found no difficulty in examining dredged areas by lines run 15 to 20-ft. apart, and maintained sometimes by compass alone. As one who has continuously used the instrument for the determination of dredging quantities, and final passing of dredged depths, he feels that he has given this machine a most exhaustive test, and that given a true knowledge of all factors concerned, an accuracy in final plotting to 3-in. of depth up to 70-ft. is definitely attainable in practice.

In concluding these remarks upon the actual use of this instrument, the independence of tidal streams should be mentioned.

In lead survey work, it is clear that good work cannot be done in a strong tide-way, for even if "up and down" casts are *apparently* obtained, sub-surface variable currents or "slacks" will "sag" the line, unknown to the Surveyor, and give him the fatal excess over true depths.

In Echo work, the shortest interval to the bottom is recorded independently of the relative movement of the water past the survey vessel, and there are therefore only three factors to be satisfied if emergecy requires a survey in a strong tide-way, as embodied in the following questions:—

(1) Is the visual tide gauge used well manned, near enough and so free from hydraulic obstruction as to assure the Surveyor of precise representative levels for the area of survey?

Echo Sounding in Harbour Hydrography—continued

(2) When the survey vessel is steering against the tide, will her essential speed through the water be increased above the " aeration " limit for the craft used?

(3) Are there sufficient shore marks, and long sensitive transits available to enable the craft to make a well-spaced pattern over the area requiring examination?

If these three questions can be answered in the affirmative, there is no reason why such a survey cannot be made in a very satisfactory manner by a seaman-surveyor.

Also, there need be no qualms about very shallow water work, providing separation error is carefully watched.

The writer has made a detailed survey of a South Coast tidal river, whose bed dried out 2-ft. at M.L.W.S., the Spring range being only 13-ft. The margins up to the points drying out 8-ft. at M.L.W.S. were included, and the results were rapid and most satisfactory.

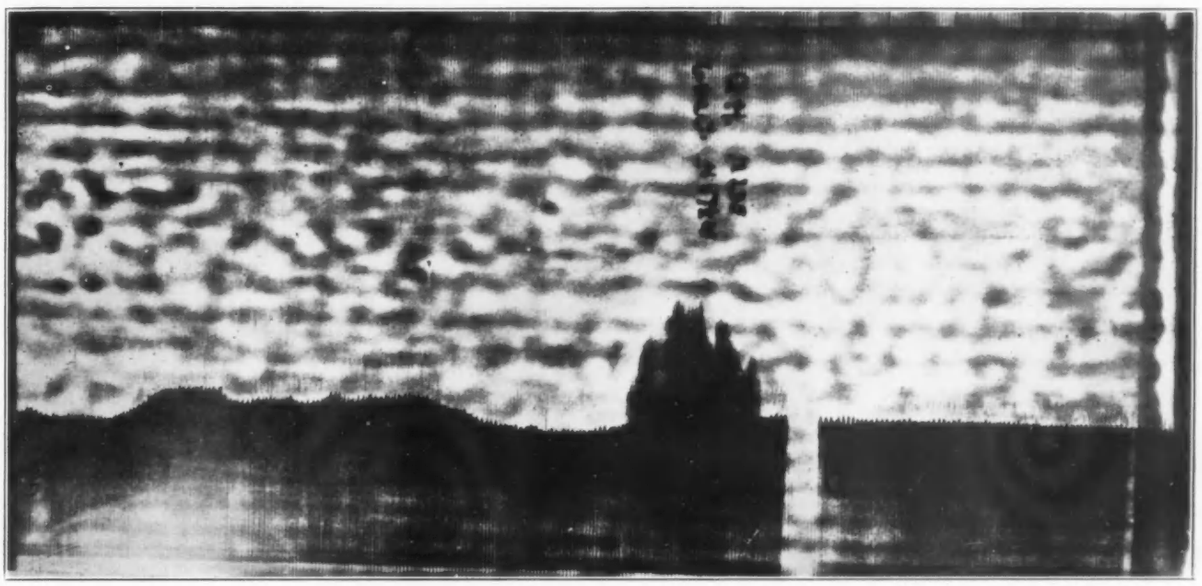


Fig. 10

When considering the maintenance of this instrument, one finds that £4 easily covered spares, and odds and ends for the first year.

The cost of Echo rolls (wet starch iodine paper) amounted to £12, but the amount of work carried out was easily four to five times that done by lead sounding.

The good weather periods were used to the full, and were sufficient to maintain a full survey programme without any " weather hindrance."

Most of the time of an Echo survey department is employed in interpreting and plotting a set of records which the drawing office sometimes, and not unnaturally, regards as a surfeit!

Efficiency, however, is well served, and the work afloat confined almost completely to ideal conditions for precise measurement without departmental slackness.

The application of Echo principles to salvage work is already proving a very great advantage to both the Port and Deep-sea Salvage Officer.

By its means, he can closely search a given area in record time, and having located a sunken vessel, can determine the least depth over it, whether it is lying upright or on its beam ends, how much of it is settled into the mud, and also by steering over it, in at most three directions, the direction it is lying on the bottom. (See Fig. 9).

If it is upright, in fairly shallow water, and he desires to make a salvage lift by camels or lighters, he can " break-down" funnel and masts by a wire sweep, and then find, by Echo sounding, the safe clearance above the hull before placing his camels in position, and heaving down for a good " lift."

In deep-sea salvage work, the name " Lusitania " is a sufficient reminder of the value of Echo " search." Fig. 10 is a reduction of an actual photograph of the record used in the location of this vessel and needs no comment.

As the M.S.X. instrument will record a bar 3-in. wide at 50-ft. quite clearly, it will not sound surprising that the writer located a lost anchor in Southampton Water after searching for 10 minutes.

The liner which had lost it during the early hours of the morning, sailed with it securely housed in the hawse-pipe the same evening.

The value of Echo work to the Harbour Officer desirous of getting about a harbour in a fog or " black-out " is immense, as the channel contours can be used by watching the Echo record and steering as requisite by compass to maintain the courses along them.

The writer knows at least one large British port where the " wreck chart " of the harbour has been much added to since Echo survey principles were instituted.

There are, however, still further applications of this instrument, one being the determination of times and places in tidal estuaries where silt in suspension is concentrated.

Not only is a light silty bottom distinguished from hard rock-like layers beneath it, but the record clouds at the points where silt in suspension—at certain concentrations—intervenes between oscillators and the bottom.

As the depth of this layer can be seen on the record, it is a simple matter to " visibly " lower a large " silt bottle " into this layer and take a sample.

Also it is possible to run lines across a certain critical section, at stated intervals, throughout, say, a 24-hour period at Spring tides and relate times in the two tidal cycles to the times of clouding, and also the depths at which this occurs.

It would appear, however, that for practical purposes the main avenue for improvement lies in the method of recording the bottom upon the wet starched iodine paper.

The makers of the instrument are, however, well alive to these problems, and research is proceeding apace.

One has no doubt, that the results will be no less complete and successful than those other achievements, so brilliantly embodied in the M.S.X. instrument.

The writer has had next to no difficulty over such minor details, and after over a year's constant use of this instrument he must, as a practical seaman and hydrographer, state it to be his considered opinion that the M.S.X. instrument is a real boon to a Harbour Surveyor and is, in his experience, the only instrument or device capable of giving an incontrovertible and readable accuracy to within 3-ft. of depth over a range of 70-ft. under way.

In saying this, however, he would again reiterate that it is most necessary to such accuracy that all the factors affecting the depth record should be mastered and considered.

The resulting accuracy and increased frequency of survey cannot fail to commend themselves to the Hydrographic Surveyors responsible for the waterways of our Ports of Empire.

Echo Sounders in River Plate Trade

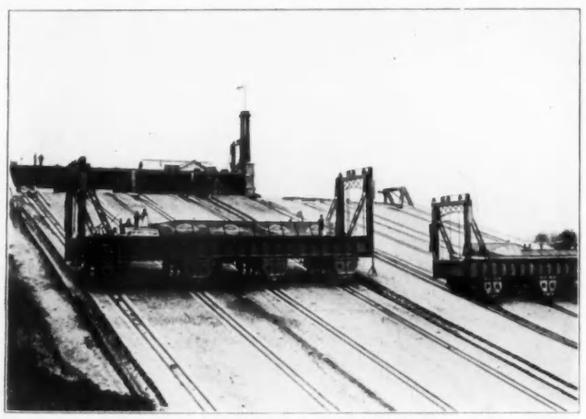
It is generally agreed by navigators that the rivers flowing into the large shallow estuary known generically as the River Plate, are among the most difficult from a navigational point of view. The Estuary itself is no respecter of ships which are inadequately equipped with navigational devices, and, as an appendix to the foregoing article, it is interesting to record that an Echo Sounder is now being adopted by important shipowners whose vessels' work is confined entirely to the Plate area. Among these is the Argentine Navigation Company (Mihanovich, Ltd.), who have recently fitted a Husun British Admiralty Pattern recording Echo Sounder, type M.S.X11C to their ship " Cuidad de Montevideo." This ship, with a sister vessel, operates a night service across the mouth of the Estuary between Buenos Aires and Monte Video, in accordance with Railway Schedule, so that accuracy of navigation is of the utmost necessity for the safety of passengers and of the ship.

*Canal Locks and other Lifting Devices in Inland Navigations**

By D. G. McGAREY

(concluded from page 274)

The Foxton Lift. A more recent case was that at Foxton in Leicestershire, which was opened for traffic in 1900 by the then Grand Junction Canal Company, and this lift incorporated several improvements over those described above. Two tanks were employed, connected to each other and to a steam-driven winding drum by wire ropes passing round a series of horizontal pulleys. In order to avoid the difficulty of the water surging in the tanks, often experienced with the usual end-on direction of travel, the tracks were in this case placed at right-angles to the longer sides of the tank. By this means also, the depth of the under-carriages was reduced and a steeper gradient made possible, allowing a shorter overall length of track. A slight disadvantage, however, was that four rails were needed to give the necessary support to each tank, these being made sufficiently large to hold two narrow boats or one barge of about 80 tons capacity. The total rise was 75-ft. 2-in., and the gradient adopted was approximately 1 in 4. With this type of lift the tank may either be submerged in a wet dock at the end of its travel, or may descend into a dry dock, kept free from water, and make a butt joint with the end of the canal pool by making contact between machined or rubber-faced ends; the butt joints are closed together by hydraulic rams or other means to give a watertight seal before opening the gates, which must be provided across the tank and canal ends. The advantage of submerging the tank is that these special joints are not required and no gate is needed at the end of the canal, but at the upper level it then becomes necessary for the tank to surmount a hump and to descend into the water, which introduces complications into the counterbalancing arrangements. At Foxton the



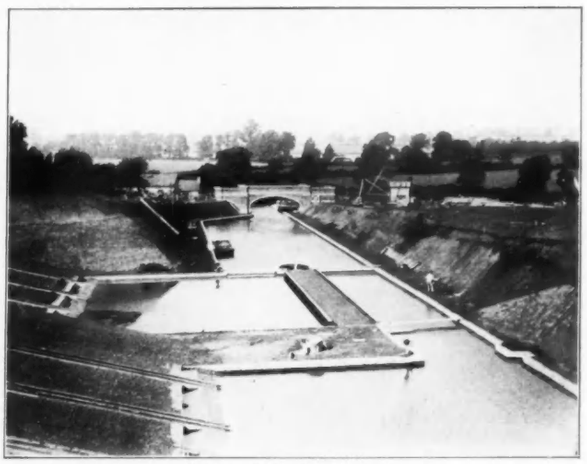
Foxton Inclined Lift.
General view showing tanks and tracks

submerging method was used at the lower end and the butt-joint at the upper, the loss of balance due to the lower tank becoming partly water-borne at the bottom of its travel being countered by easing off the gradient of the tracks at the top. With the two gates of the butt-joint method it is necessary to admit water into the space between them before they can be opened, in order to overcome the unbalanced water pressure, which otherwise would cause friction and prevent their being lifted.

Vertical Lifts

An early example of a vertical lift was at Tardebigge on the Worcester and Birmingham Canal, where in 1809 a lift was constructed, consisting of a wooden tank 72-ft. by 8-ft. by 4-ft. 6-in., supported by chains passing over cast iron pulleys, the other ends of the chains being attached to counterbalances consisting of masses of brickwork on timber platforms. The rise was only 12-ft., and the lift, which was worked by winches and ropes, has since been replaced by locks. Seven lifts on the Grand Western Canal, near Tiverton, were constructed in 1834, the rise being 46-ft. Counterbalanced double tanks, holding boats 26-ft. by 6-ft. 6-in. by 2-ft. 3-in., were employed, the lift being set in motion by admitting about 2-ins. of extra water into the upper tank.

The Anderton Lift on the Weaver Navigation in Cheshire is the only example of a lift now in use in this country, and this was constructed in 1875 to make communication between the River Weaver and the Trent and Mersey Canal. Two tanks built up from wrought iron plates, sufficiently large to carry one 100-ton barge or two of the usual 40-ton boats, were supported on hydraulic rams 3-ft. in diameter, counterbalancing being effected by a valve connection between the two cylinders.



Foxton Lift, lower pools

At the lower end the tanks submerged in the water, but at the upper end a butt-joint was made with the end of the canal pool. The lift was set in motion by admitting 6-ins. of extra water into the upper tank, but as soon as this had descended and had commenced to submerge, the out-of-balance load was taken up by the displacement of the water. The travel was therefore completed by means of hydraulic power from an accumulator used also to supply the rams which closed up the butt-joints.

In 1908, however, electric power was substituted, a full account of the reasons for this, and of the reconstructed lift, being given in Vol. CLXXX of the Proceedings of the Institution of Civil Engineers, but a brief description will no doubt be of interest. The main reasons for discontinuing the hydraulic machinery, which had given good service for thirty years, were grooving of the rams, gradual softening of the metal of the cast-iron cylinders, continual breakages of the pressure pipes and connections, and serious disintegration of the main girders which conveyed the weight of the tanks on to the heads of the rams. It was decided to take advantage of the opportunity given by the reconstruction to make the tanks work independently, each being now separately balanced by means of wire ropes passing over pulleys and connected to iron counterweights. The former method of submerging the tank at the

Foxton Lift. Tank submerged in lower pool, gate closed ready for ascent

bottom of its travel was given up in favour of the dry dock in order to keep the load of the tanks constant. Five columns on each side of the pair of tanks were securely braced together and supported a grid of girders constructed to carry a series of

* Paper read before the Junior Institution of Engineers on 11th March, 1938.

Canal Locks and other Lifting Devices in Inland Navigations—continued

pulleys 6-ft. in diameter. These pulleys in turn carried the wire ropes, attached at one end to the tanks and at the other to the balance weights, and the whole suspended load due to the weight of the tanks, water, boats and counterbalance weights amounted to some 1,650 tons. A single electric motor of 30 h.p. was connected by shafts and double-helical gearing to the pulleys, and the friction of the ropes passing over them was relied upon to give a positive drive to the tanks. One 7-ton counter-weight was suspended from the other end of each rope, and no "creeping" was anticipated or experienced. The total lift of 50-ft. 4-in. was accomplished in a little under six minutes, or at the rate of about 8½-ft. per minute. The original tanks were retained in the reconstructed lift as the large number of ropes gave a more even distribution of weight, and the stresses in their girders were thus reduced. Automatic hooking arrangements allowed the two gates of the tank and pool to be locked together as the tank was brought home, and a single electric motor then lifted them together, lifting being automatically prevented until the locking had taken place. The lift has now been working continuously for thirty years, and is undoubtedly a satisfactory type of machine.

Foxton Lift. Upper pools, boats passing out of tank after ascent, gate shown lifted for the purpose

The Henrichenburg Lift. On the Continent many lifts of considerable interest have been constructed from time to time, notably, a recent example at Niederfinow, but space will permit only of the mention of one example, and a lift of somewhat different type has been selected for a short description. The Henrichenburg Lift in Germany comprises a trough supported on five hollow wrought-iron floats, 29-ft. in diameter and 43-ft. high working in separate wells. The well shafts are 30-ft. diameter and 96-ft. deep, lined with concrete at the top and cast-iron segments for the lower portions, and are connected together by pipes nearly 5-ft. in diameter. The trough rises and falls between five braced columns on each side, opposite columns being connected together overhead as portals, and is actuated by power-driven vertical screwed shafts rotated simultaneously through overhead gearing. The trough is 230-ft. long by 29-ft. wide, and can hold ships of 900 tons having a draught of 7-ft. 6-in.; the total lift is 48-ft., and the speed attained about 20-ft. per minute. The total weight lifted is 3,100 tons, of which 1,540 are due to the water and boat, 800 to the trough and 760 to the floats. The trough is made tight to the canal pool by means of a "U"-shaped frame of wedge cross section, which is lifted into position between the end of the tank and a fixed frame at the end of the pool.

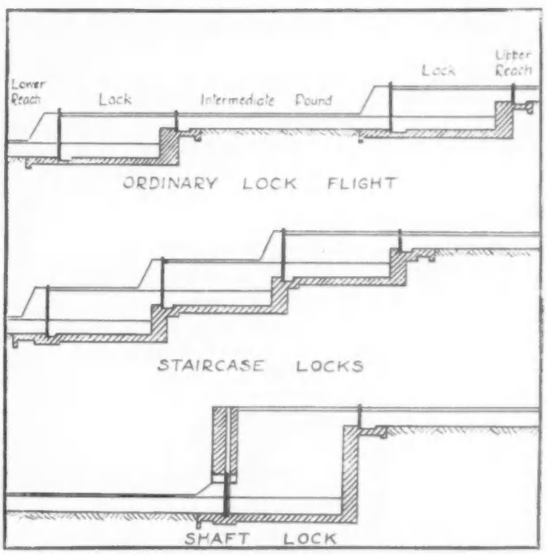
Comparison of Lifts with Locks

The subject of Canal Lifts seems to be one which attracts all the resources of the inventor's fertile brain, and endless schemes have been put forward at various times, especially on the Continent, where conditions generally are more favourable to their economical employment. In spite of the ingenuity of engineers —and others—however, it cannot be said that lifts have taken the place among canal lifting devices which one would expect, the tendency being, in this country at least, to rely on the essential simplicity of locks and to extend their range of usefulness by paying special attention to methods of economising in time and water. Before leaving the subject of lifts, however, it may be as well to recapitulate concisely the respective merits of the two systems.

Locks have the great advantage of simplicity and cheapness, the latter applying, however, more especially to working costs. they do not ordinarily require any machinery, or auxiliary power, with consequent attendance and supervision, and by their use canals can be made to follow any desired route, the total rise or fall being taken in steps at varying intervals to suit the local ground levels. On the other hand, they use considerably more water, and the time taken to pass through a flight of locks is also greater, as a rule, than that taken in a single lift, and depends on the number of locks rather than on the overall length of the flight. These advantages can, however, be minimised when necessary by auxiliary devices. Lifts have the advantage of economising both in time and water, but are expensive and more liable to mechanical defects, and stoppages for repairs or on account of a sudden breakdown may completely disorganise the flow of traffic. In general, lifts can only be considered to be economical where considerable changes of level occur within a short distance and where traffic is sufficiently heavy to pay for the higher working costs.

LOCK DESIGN

It will be appreciated, therefore, that, apart from giving the necessary mechanical strength and durability to the various lock components, the chief objects of modern lock design are to enable quick passages to be made and to effect economy of water. These two objectives are to some extent antagonistic, and a decision must be made in most cases as to their relative importance, so that in situations which may be similar topographically different traffic or water supply conditions may result in different types of lock being employed. There are, in both of these considerations, two aspects of design to be dealt with, firstly, what may be termed the "group design" of a series or flight of locks, by which is meant the choice of a suitable rise for the locks, their distance apart, whether duplicate locks will be required, the advisability of staircase flights, and so on. Secondly, there is the detail design of the individual locks of the series. Space will not permit of the description of all the various components, but these questions of group and individual design and water economy are of prime importance and warrant further study.



Lock Flights

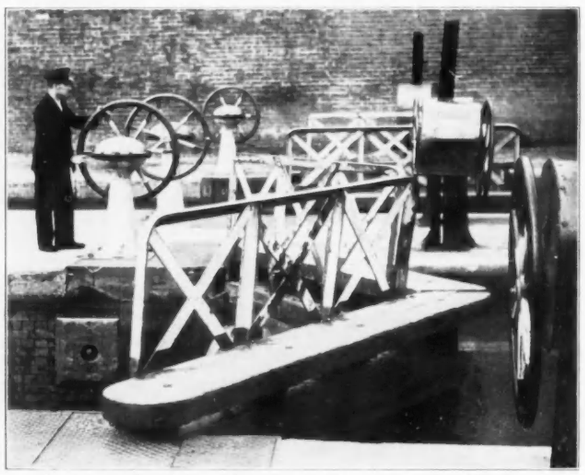
Traffic considerations alone would suggest the use of few locks of large rise rather than the reverse; operating times are not greatly increased with deeper locks, so that the fewer there are the quicker the flight may be surmounted. On the other hand, more water is consumed at each locking operation and no saving is possible on account of the smaller number, as in any case the water used at the top lock of a flight is available for working the remainder in turn. Where water supplies are poor, it is economical to employ a greater number of locks of comparatively small rise. Where larger rises are necessary, however, a certain saving in water can be made if required by careful regulation of the traffic; for example, if up-hill and down-hill boats are made to pass alternately two passages can take place at each complete locking, whereas with random traffic the occurrence of two or more up-hill passages in succession is quite possible, and entails the consumption of a full lock of water for each boat. For the same reason, in the case of barge locks, narrow boats would not be admitted singly, but would be made to wait until another going in the same direction arrived, so that the pair might be lifted or lowered together at one operation. In practice such regulation of locking operations can save a considerable amount of water, possibly up to 30 or 35 per cent., but it has an adverse effect, of course, on the journey times of the individual boats.

Where traffic is heavy duplicate locks are sometimes employed, thus doubling the capacity of the lock flight, and to a certain extent these afford opportunities for water economy even without any particular traffic regulation, as boats in either direction will, in most cases, find one or other of the two locks

Canal Locks and other Lifting Devices in Inland Navigations—continued

ready, instead of possibly having to empty or fill one specially before entering. A further advantage of duplicate locks in this respect will be mentioned later.

Staircase Locks have the advantage of needing only half the number of gates as compared with a flight of separate locks, and thus save the time needed for their opening and closing, but have other characteristics which are not conducive to the attainment of either of the main objectives. It is not possible for one full-sized boat or barge proceeding up-hill to pass another going down-hill, so that unless several boats are ready to succeed one another in the same direction at close intervals time is lost on the whole owing to the need for waiting until a boat has completed the full ascent before the descent of another can be commenced. Again, a boat going up-hill leaves each chamber full behind it, whereas a down-hill boat leaves each chamber empty, so that at each reversal of direction the consumption of water amounts to as many lockfulls of water as there are chambers in the flight. In the case of a flight of separate locks, spaced out by intermediate pounds, the pounds act as storage reservoirs in between the two passages, and one lockfull of water only is used throughout the whole flight. For these reasons staircase locks are most suitable where they can be reserved exclusively for use in one direction only, and if this type is considered essential then duplicate flights, one for each direction, should, if possible, be provided. Generally, artificial regulation of traffic is undesirable as it tends to waste time and necessitates the employment of additional labour in supervision, and, apart from emergency or occasional use, it is not resorted to in practice. Where the dimensions of the locks are determined by other considerations and the water supply is then found to be insufficient, it is sometimes necessary to resort to pumping back lockage water from the bottom to the top of a flight, but in a long flight the cost may easily become prohibitive, and it is therefore desirable, wherever possible, to make provision in the design of the individual locks for the maximum possible conservation of water. In the first place, however, the possibilities of hastening locking operations will be considered before going further into this problem.



Hand-wheels and gearing for operating gates and sluices, at Brentford Locks, G.U.C.

Individual Locks—Speed of Operation

As far as the design of a lock flight is concerned, it has already been pointed out that speed of operation may be assisted by using a comparatively small number of locks of relatively large rise, and by providing duplicate locks in cases of heavy traffic. In the individual design, however, it is the total time occupied from entering until leaving which must be reduced, and this depends, firstly, on the time taken for the water to fill or empty the chamber; secondly, on the rate at which the sluices and gates can be operated; and thirdly, on the speed with which the boats can enter and leave the lock.

Filling and Emptying Locks. Water is admitted to the chamber or released from it by means of sluices, which may either be placed in the gates or in culverts passing round the back of the hollow quoins, the former method being the cheaper, and was the one generally adopted on most English canals. On the locks of the old Grand Junction Canal, now part of the Grand Union system, for example, two sluices operated by rectangular paddles are fitted in each of the upper gates and one larger one in the lower gates, the reason for splitting the upper ones being the necessity for reducing the amount of water rushing into the lock chamber at one point which otherwise might result in swamping the boats.

Many of these locks are also equipped with culverts at the top ends opening into the lock chamber just below the gates, the paddles, known as ground paddles to distinguish them from the gate paddles, working over the culvert mouth, which is situated in the top gate recess. By the simultaneous operation of all six paddles at the top end the lock may very quickly be filled, but a good speed can be achieved when emptying the lock by the use of the two larger lower gate paddles only, as besides the increased area of opening the water has a much more free path of discharge. The best results are, however, obtained by the use of properly designed culverts constructed behind and parallel to the walls, having several openings into the chamber, and on the fifty-one recent locks on the Warwick Section of the Grand Union Canal this form of construction has been adopted. The top end culverts, one on each side of the lock, are 2-ft. 9-in. square, and three openings from the lock chamber into each culvert are provided. Similar culverts and sluices are provided at the lower ends but have only one opening from the lock, and these large sluiceways ensure rapid emptying and filling. No paddles in the gates are provided, or indeed are necessary, thus making for considerable saving in gate maintenance.

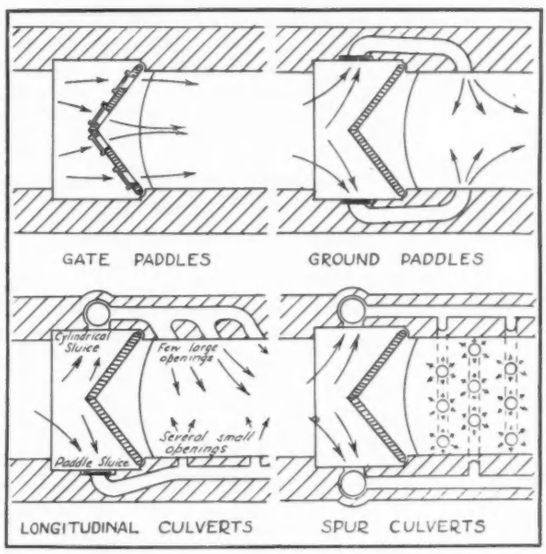
In larger locks care must be taken to ensure an even distribution of water as it flows into the chamber when filling, in order to improve the mean velocity in relation to the maximum velocity, and also to reduce turbulence and eddies. The sluice culverts are therefore sometimes extended to the full length of the chamber with several openings at intervals throughout, or in other cases water is admitted only at the top end through some form of stilling chamber behind the head-wall. Still larger locks, as for example the Panama Locks, add short spur culverts under the lock floor branching off from the main culverts, and communicating with the chamber by means of a series of vertical pipes, thus giving a very uniform and steady flow. It is not so essential to arrange for smooth flow when emptying the lock, and provided that the water can get away quickly no special precautions need be taken. Plain gate paddles are quite effective and are often used in the lower gates, but usually mean an increase in the cost of gate maintenance.

Sluice and Gate Operation. The design of the sluice and gate operating gear is, of course, the dominant factor in influencing the time taken under the second heading, and many different types are in general use. The majority of canal locks are provided with paddles working over apertures either in the gates themselves or at the entrances to the sluice culverts, and these paddles, in the oldest patterns, were raised and lowered by means of a simple lever, but the more common practice is for some form of rack and pinion motion to be employed. This is usually actuated by a portable crank handle carried by all boatmen, but where a regular lock-keeper is employed a hand-wheel, permanently geared to the pinion, is an advantage. The latest locks on the Grand Union Canal have totally enclosed gearing, the paddles being operated by screwed rods through bevel gearing, and a considerable number of experiments were performed at the maker's works before the design was finally settled, in order to determine the optimum ratio of the gears. If they are geared too high they become too heavy for one man to operate, while if they are too low the lock will have filled before the sluice has been opened fully. The ratio giving the most effective balance between these two extremes was found to be that requiring 36 turns of the handle for the paddle to be lifted through its full height of 2-ft. 9-in. Another type of sluice has been used to a considerable extent in larger locks, the object of which is to obtain the maximum possible area of opening with the minimum height of lift. The actual culvert mouth is in the shape of a horizontal circular opening, the sluice itself being a cylindrical drum which, when shut, rests on the rim of the opening. It is a well-known fact that an opening equal in area to the cross section of the culvert will then be obtained with a sluice lift of one quarter the diameter of the culvert mouth, as against a lift equal to the full diameter in the case of an ordinary flat paddle. Besides the advantage of a small lift, moreover, the friction caused by water pressure in the paddle type is avoided, as the uniform radial pressure all round the cylinder is self-balancing, and the effort of lifting is therefore reduced, with a corresponding gain in efficiency. Such sluices are employed on the Panama Canal, and have also been much used in locks on the Continent; an instance of their use in this country is on the Weaver Navigation, where the large locks previously described are so equipped. In this case where the rise of the locks is 8-ft. 6-in., each lock is equipped with six wrought-iron cylindrical sluice gates 5-ft. 6-in. diameter, while on the Scheldt-Meuse Canal they are 5-ft. 8-in. diameter, and the full lift 1-ft. 3-in., the lock being thereby filled in two minutes.

The design of the gates has a considerable bearing on the speed with which they can be opened, and whereas the common mitred gates may quickly be swung aside other types are usually slower in operation. On river navigations which are subject to floods radial or vertical lifting gates are sometimes found, but while these are admirable for discharging water quickly and at a uniform rate, they must be lifted bodily to a considerable height in order to give clearance above the water before boats

Canal Locks and other Lifting Devices in Inland Navigations—continued

can pass in or out. It is, of course, possible, if desired, to apply mechanical power to replace the customary manual labour, but as a rule the latter is quite efficient for all operations connected with the smaller locks, and electric or hydraulic drive is generally only applied to ship locks where the moving parts are too cumbersome to be otherwise dealt with. For instance, the cylindrical sluices on the Weaver Navigation locks are counterbalanced and can easily be raised to their full height by one man in four seconds, and in the case of gates even comparatively large ones can easily be operated by hand either by leverage on the balance beam or by hand-wheels through gearing. Furthermore, there are comparatively few instances of canals where auxiliary power is readily available at the lock sites, and even where is is considered desirable, it has to be borne in mind that the installation of any machinery at a lock necessitates the services of a full-time lock-keeper or mechanic whereas the usual manual equipment is worked by the boatmen themselves.



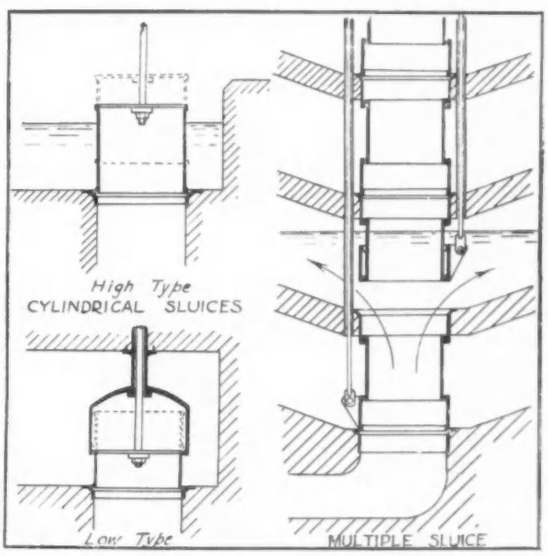
Entering and Leaving the Lock. As far as the general design of the lock can effect it, the time under the third heading may be improved by providing a cross sectional area of water in the lock chamber rather greater than the mid-ship section of the boat, in order to give sufficient clearance for the water in the lock to be readily displaced by the incoming craft. It is preferable to give this by increasing the depth on the sills rather than by allowing a greater width between the side walls, as traders are apt to take advantage of the latter by building wider boats, thus defeating the object sought for, whereas the draught is usually restricted by the depth of the canal itself. Apart from seeing that the alignment of the lock gives reasonably good approaches, and that a sufficient number of strapping posts or bollards are provided, little more can generally be done, but where an external source of power is available then the installation of a capstan will often speed up this part of the operation appreciably. At Brentford, where the Grand Union Canal joins the River Thames, craft are assisted through the lock at the junction by means of a hydraulic capstan, and when the tide rises sufficient to make a level, enabling both pairs of gates to be opened together, the capstan is especially helpful in pulling barges straight through the lock in quick succession At the lock next above a 2-ton electric capstan with fluid flywheel coupling has recently been installed, and a marked improvement in the handling of the largest barges, which often carry in excess of 100 tons and fit the lock very tightly, has been the result. As an extension of this principle to larger locks, the Panama Canal may again be instanced, in which vessels are towed through the locks by means of electric locomotives running on tracks parallel with the lock sides.

General Conclusions

Locks vary so much in size and working conditions that no hard and fast rules can be laid down, nor is it possible to say definitely which of the three factors mentioned above is of the greatest importance, especially as in practice the individual operations tend to overlap. In general, however, it may be said that well-designed sluices and culverts are a sound investment, as at practically no increased cost greatly improved results may be obtained. Power-driven sluice and gate gear is warranted as a rule only in the larger locks, but attention should be paid to the balancing of gates, counterbalancing of sluices and to the gear ratios of their operating wheels and mechanical details generally. Lastly, where traffic is heavy and where auxiliary power is available, the provision of capstans is indicated, although great care must then be taken to avoid damage to the gates by over-running, and regular supervision by a competent operator is imperative. As an instance of what may be accomplished without the aid of mechanical power or auxiliary machines of any description, it may be said that a pair of boats can be passed through one of the new locks on the Grand Union Canal in less than three minutes, the actual filling or emptying of the lock taking about a minute and three quarters. The whole twenty-one locks of the Hatton flight, extending over a distance of two miles, can be passed through in about an hour and twenty minutes, making an average time of four minutes per lock, from which must be deducted just over a minute for travelling time between the locks. In other words, the total time lost in negotiating the flight, compared with travelling on the level, is only about fifty minutes, or an average of $2\frac{1}{2}$ minutes per lock.

Individual Locks—Economy of Water

The other main object of lock design is to effect the necessary locking operations with the minimum possible expenditure of water. In a simple lock the volume of water used at each operation is equal to the plan area of the lock between the inside faces of the gates multiplied by the rise between the top and bottom levels—the whole of this water passing from the upper to the lower reach at each complete cycle of filling and emptying. Where natural water supplies are insufficient and it is desired to afford some relief other than by traffic regulation or pumping, as mentioned in connection with " group " design, there are three principal modifications of the simple lock which enable this to be accomplished, these being Duplicate Locks, Side or Economiser Pond Locks, and Shaft Locks respectively. When a simple lock is emptied the whole of the potential energy of the water in the chamber is dissipated, and at the next filling this is replaced from the water in the top level, only to be lost again at the next operation. By letting only part of the water run into the lower reach, and by storing the remainder at a higher level, some of this energy is conserved; the stored water is available for partly filling the lock again, and the total amount drawn from the top level is thus reduced. The three methods just referred to actually represent three stages in the development of the energy storage principle.



Duplicate Locks. Where traffic is comparatively heavy, it is often desirable, as previously mentioned, to construct duplicate locks, side by side, at each change of level. When this is done it is convenient to provide a central paddle communicating between the two chambers, and by its use the consumption of water may be reduced. Assuming that one lock is full and the other empty, each holding a boat, the gates are shut and the centre paddle only is raised; the water then passes from the full lock into the other until the same level in each is reached. By closing the centre paddle and opening the lower paddles of the descending lock the remainder of the water passes out, and it is thereby emptied. Similarly, the filling of the other lock is completed from the top reach, and thus a complete double operation has been carried out with the expenditure of half a lock only of water. In actual practice the saving is rather less than half a lock, as it would take too long to wait until an exact level had been made between the two locks before completing the operation by means of the top and bottom paddles. Unless traffic is fairly well balanced between up-hill and down-hill at the same time, however, the requisite pair of barges may not always be available together. If one boat only is ready to pass through, the top half of the lock can be run off

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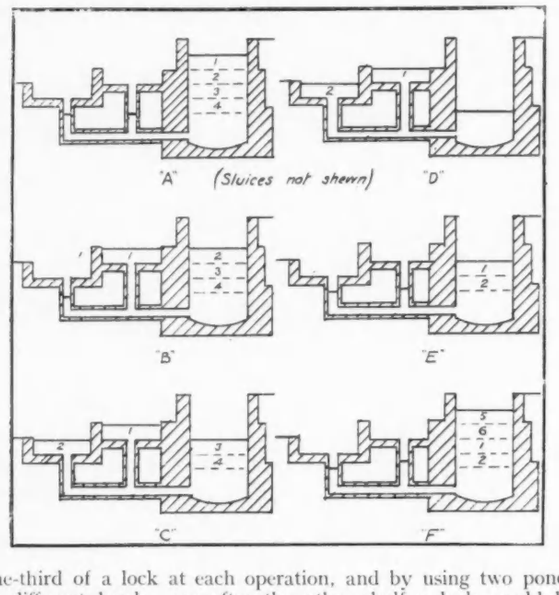
into the adjacent chamber, which is subsequently filled from the top level and made ready for the next boat, and the bottom half run off as usual. The result is that the saving of half a lock is made only on a single operation. This system again depends for effective economy on the possibility of traffic regulation, but if traffic is heavy, urgent, or irregular, it loses much of its efficiency.

Side Pond Locks. Where the amount of traffic does not warrant the construction of duplicate locks, as in the majority of cases, the advantage of that method may be obtained by constructing alongside the lock proper the equivalent of a dummy lock, consisting of an open pond or tank of approximately the same area as the lock chamber and connected to it by a sluice; this is called an economiser pond, or side pond, or sometimes a thrift pond. As before, the top part of the water may be run off into the side pond and the remainder into the lower reach, and for re-filling the side pond is emptied back into the lock and the operation completed from the top reach. With one pond it is, theoretically, possible to save



one-third of a lock at each operation, and by using two ponds at different levels, one after the other, half a lock would be conserved. Here again, however, the full saving cannot ordinarily be made, as the time taken for the last drop of water to flow into or out of the pond would be out of proportion to the advantage to be gained, and the practical efficiency is generally about three quarters of what is theoretically possible. By providing three side ponds to a lock, it is quite possible to halve the consumption of water, and locks so equipped are in general use, but the time and labour involved in operating the extra paddles, in addition to the gate paddles, becomes a nuisance and renders any greater number too cumbersome. Often two ponds only are provided, allowing a saving of about one-third of a lock, and by the combined use of traffic regulation and careful operation of the side ponds a very considerable saving in water can be made, amounting, possibly, to some 60 per cent.

Shaft Locks. If it were possible to increase indefinitely the number of side ponds, the quantity of water used for a given rise of lock would be correspondingly decreased, and in general, if there are "n" ponds it can be demonstrated that, theoretically, the amount of water consumed would be $\frac{2}{n+2}$ of a lock.

Conversely, the principle can be applied to the construction of exceptionally deep locks, for example, a lock equipped with eight side ponds and having a rise of, say 40-ft., would consume no more than one without ponds, and having a rise of only 8-ft. In effect, five locks of normal rise are superimposed and combined in one to form a deep shaft in which the whole operation can take place, thus reducing both operating time and construction costs, and a shaft lock with such a series of side ponds may thus be an economical proposition, although, as stated above, not desirable for locks of more normal rise. A means is thus made available whereby locks may be constructed to surmount rises usually considered suitable only for vertical lifts, and yet with very little more expenditure of water. In recent years this idea had been adopted on the Continent, and plans have been prepared for locks of very large rise, one or two examples being actually in operation. The ponds are usually constructed in reinforced concrete in series on either side of the lock, or where a large number is involved they are preferably placed one over another, communication with the lock chamber being effected by means of a vertical culvert and a series of cylindrical sluices.

The great advantage of the shaft lock over the vertical lift is that there are no moving parts, necessarily of great size and weight, to be dealt with, the only items subject to wear and tear being the gates, which can be made exactly after the pattern of normal lock gates, the lower end being dealt with after the manner of the deep French lock previously referred to, and the sluices. Alternatively, the gates may be of the lifting type, for which there would be ample accommodation at the lower end, or the upper gates may be of the trap door or flap-up pattern. The great disadvantage would be the number of sluices to be operated in correct sequence and without loss of time, and this would seem to suggest the development of a series of self-acting automatic sluices operated by the varying water pressure in the lockshaft. No machinery requiring an external power supply would be necessary, and no costly but idle counterbalance weights or complicated system of wire ropes and gearing. The idea is applicable to almost any difference in level likely to be met with, at a cost very nearly in proportion to the rise adopted, so that if necessary a large difference in level might be surmounted in two or more stages to suit route conditions at little extra expense.

Conclusion

It seems quite possible that in many cases the ultimate solution of the whole problem of overcoming considerable differences in level, taking into account cost, speed of operation, and reasonable economy of water, will be found in such a development of the shaft lock.

One may confidently say, therefore, that the lock, representing, with its variations and different applications, literally centuries of invention, experiment and development, still holds its own as a technical appliance, and yet has potentialities which makes it worthy of the attention of every engineer.

Defence of Transport against Air Attack

In connection with the Paper by Wing-Commander E. J. Hodsoll, C.B., on Defence of Transport against Air Attack, read before the Institute of Transport on March 28th last, the following observations were contributed by Mr. R. P. Biddle, the Docks and Marine Manager of the Southern Railway Company, at Southampton:—

The author has not under-estimated the difficulties where dock operations are concerned, but it must be agreed that much can be done to minimise danger and lessen possible loss of life, and perhaps equally important to reduce chaos, confusion and loss of morale which might otherwise be created.

As the result of an exercise recently carried out at Southampton in co-operation with the Portsmouth Naval Authorities and the Southampton Municipality, interesting data was obtained from the experiments made with a modified form of lighting.

Two experiments were made, one at a cargo working berth and the other in one of the shunting yards. At the cargo berth twelve electric light fittings were temporarily fixed to the crane gantries, 300-watt lamps being inserted, and a glass plate which had been dipped in special blue paint was placed on the underside of the fitting. The result was a soft blue illumination almost entirely free from glare, and possibly practically invisible from the air. Unfortunately fog prevented aerial observation being made. It was considered that shipping operations could be carried out under these conditions at probably 70% of normal efficiency.

In the shunting yard five standard fittings were used, the power of the lamps being reduced from 1,000-watts to 300-watts and the outer globe treated as in the case of the cranes. It was considered that sufficient light was reflected on the points and crossings to enable shunting to be performed at possibly 60% of normal efficiency. Shunters' hand lamps were smoke-screened leaving a small ring on the outer side of the lamp glass for light to penetrate, and engine fire boxes were shrouded. Both experiments were most effective.

As regards traffic aids, vehicles were sent over pre-selected routes and reports submitted as to the value of certain aids. Summarising these reports it would appear that lavish use of white paint has excellent results, white lines in the centre of roads being the most helpful to drivers, and white barriers placed at dangerous points such as at the approaches to dry docks could easily be seen at a distance of fifteen yards. Concrete roads proved an excellent aid in themselves, and drivers were quite happy to continue with no head or side lights.

In conclusion, I would emphasise the immense value of such exercises. At Southampton many lessons were learned which will be most helpful in preparing schemes and carrying out future tests on similar lines.

Maritime Timberwork

The Report of the Forestry Commission (Utilization Series No. 4) on the Demand for Timber in Ship-building and in Docks and Harbours (published by H.M. Stationery Office, price 1s. 3d. net), is the fourth of a series of investigations undertaken on the recommendation and under the supervision of the Inter-Departmental Home-grown Timber Committee. The enquiry was carried out during the latter part of 1936 and intermittently in 1937.

The first part of the report, containing the section on Docks, Harbours and Canals, is of most interest to readers of this Journal. It gives the consumption of timber during the period of the last completed year in the Civil Engineer-in-Chief's Department of the Admiralty on the maintenance of H.M. Naval Establishments in Great Britain, the chief of which are the four dockyards at Chatham, Sheerness, Portsmouth and Devonport. It is interesting to note that out of a total consumption of 308,218 cu. ft. of timber, one-half (151,470 cu. ft.) was Douglas fir of Canadian origin and one-third (107,085 cu. ft.) European red fir; no greenheart, apparently, and only 339 cu. ft. of Jarrah.

The specification for British timbers used by the Admiralty is as follows:—

> "British ash to be white, young and of straight growth, and wide ringed.
>
> "British elm to be good, sound, clean, fresh cut as required (and not more than 12 months in stock), of the varieties known as common elm, wych or Scotch elm, merchantable, free from sharp bends and warp, and containing not more than 10 per cent. of sapwood.
>
> "British oak to be seasoned, preferably for at least three years in log or two years in plank. It is to be bright in colour, with a hard, firm and glossy surface and generally free from sapwood. To be quarter-cut when so ordered from specially seasoned oak.
>
> "Scots pine to be of fairly close grain and containing not more than 10 per cent. of sapwood.
>
> "Spruce, white fir or white deal to be of fairly close grain and containing not more than 10 per cent. of sapwood."

The Railway Companies have supplied particulars, given in summarised form, of the timbers used in the maintenance of their harbours, from which it appears that there are large purchases of pitchpine, British Columbia pine, redwood (Scots pine) and deals, with smaller quantities of greenheart and Jarrah.

Among the seven larger Dock and Harbour Authorities (excluding Railway Companies) whose returns are tabulated, there is a gross annual demand for maintenance purposes of 188,414 cu. ft. of timber, including 52,908 cu. ft. of redwood (Scots pine); 46,480 cu. ft. of spruce; 33,852 cu. ft. of pitchpine; 14,624 cu. ft. of Douglas fir; 11,144 cu. ft. of Baltic fir (Scots pine); 7,065 cu. ft. of greenheart; 8,739 cu. ft. of oak, and 7,394 cu. ft. of elm. Pyinkado is mentioned, but the quantity is trifling.

In addition to the foregoing, visits were made to 38 other dock and harbour authorities along the coastline, from which the following observations were deduced:—

> "The chief purposes for which the authorities need supplies of timber are the replacement of piles and fenders and repairs to piers, jetties and landing stages. In a few instances there are dock gates to be repaired, sleepers to be replaced, and fish dock floors and walls that need to be patched up. Also there are occasional minor requirements, such as repairs to beach groynes, replacement of treads on bridges, and of beds for bollards. A few harbour authorities maintain repair yards for the dredgers and barges and other craft which they employ, and wheelwright shops for mending carts and barrows.
>
> "For piles, 16 of these authorities are using greenheart and 14 pitchpine; turpentine was noted twice, and Oregon pine, Jarrah and home-grown oak once each. Several use ferro-concrete piles, and only employ timber where the concrete is not suitable. A frequent size for piles is 14-in. square, and they may be required from 35 to 60-ft. in length. The one place where home-grown oak was being used is on the East Coast; the quay piles there are 14-in. square, and quay wales (also of oak) are 12-in. by 12-in.
>
> "For fendering and waling, 11 of the authorities visited use home-grown elm. Commonly, but not invariably, the term fender applies to protective baulks placed vertically against a harbour wall, while those placed horizontally are called wales or rubbing-pieces. Some dimensions noted are 12-in. and 10-in. by 6-in., 18-ft. to 26-ft. long. In one instance, Flemish elm is used in preference to home-grown, and five authorities employ pitchpine. It is stated that home-grown elm is particularly liable to attack from the marine borer.
>
> "The decking of wharves and jetties is usually either pitchpine, Oregon or Jarrah, but, twice in Scotland, home-grown larch was noted for this purpose. Bracings and struts, so far as noticed, are of pitch and Columbia pine; and sleepers of fir, usually Baltic, but in one case described as Douglas fir. For repairs to dock gates, greenheart is most in demand; home-grown oak is used sometimes for sills and bollard beds, and home-grown ash to a small extent for wheelwright work. Australian brush box was mentioned in one instance as useful for fish-loading platforms and teak for staircases."

Wellington Harbour Board, New Zealand

Excerpts from the Annual Report of the General Manager and Secretary for the Year ended 30th September, 1937

Trade of the Port

Two records were established this year in connection with the trade of the port; firstly, in the tonnage of goods and secondly, in the tonnage of shipping arrivals. The total trade inwards and outwards amounted to 2,311,076 tons, an increase over last year of 298,616 tons, or 14.8%, and the net tonnage of shipping arrivals was 4,090,307 tons, an increase of 4.6%. These tonnages are not only a record for the Port of Wellington, but exceed those of any other port in the Dominion.

Imports of all classes totalled 1,295,492 tons, an increase of 200,978 tons, or 18.4%; and Outward cargo of all classes totalled 588,280 tons, an increase of 49,406 tons, or 9.2%.

Shipping Arrivals

The total net register tonnage of trading vessels entering the port during the year (excluding 98,212 tons representing warships, lighters, private yachts, etc.), amounted to 4,090,307 tons, which is 179,506 tons greater than last year. For comparison with those ports combining the arrivals and departures, the total net register tonnage of trading vessels that arrived and departed from and to overseas and coastal ports during the year was 7,939,427 tons.

Export Values

The total value of all overseas exports from the Port of Wellington for the year ended 30th September, 1937, was, from H.M. Customs returns, £16,071,093 (including £3,500 specie), compared with £13,575,461 last year, an increase of £2,495,632.

Import Values

The total values of all imports, including specie, computed in New Zealand currency, during the year ended 30th September, 1937, was £21,033,504, compared with £14,996,395 for the previous year, an increase of £6,037,109.

The total value of New Zealand imports during the year ended 30th September, 1937, was £54,429,386, and of exports £65,994,303, so that over 38% of the total imports and 24% of the total exports passed through the Port of Wellington.

Financial Results

Receipts for the year were £558,749 9s. 11d., an increase of £79,761 10s. 0d., and the expenditure £547,577 7s. 9d., an increase of £87,506 18s. 4d. The surplus on the year's working was £11,172 2s. 2d., compared with £18,917 10s. 6d. last year.

Wellington as Trans-Tasman Flying-boat Terminal

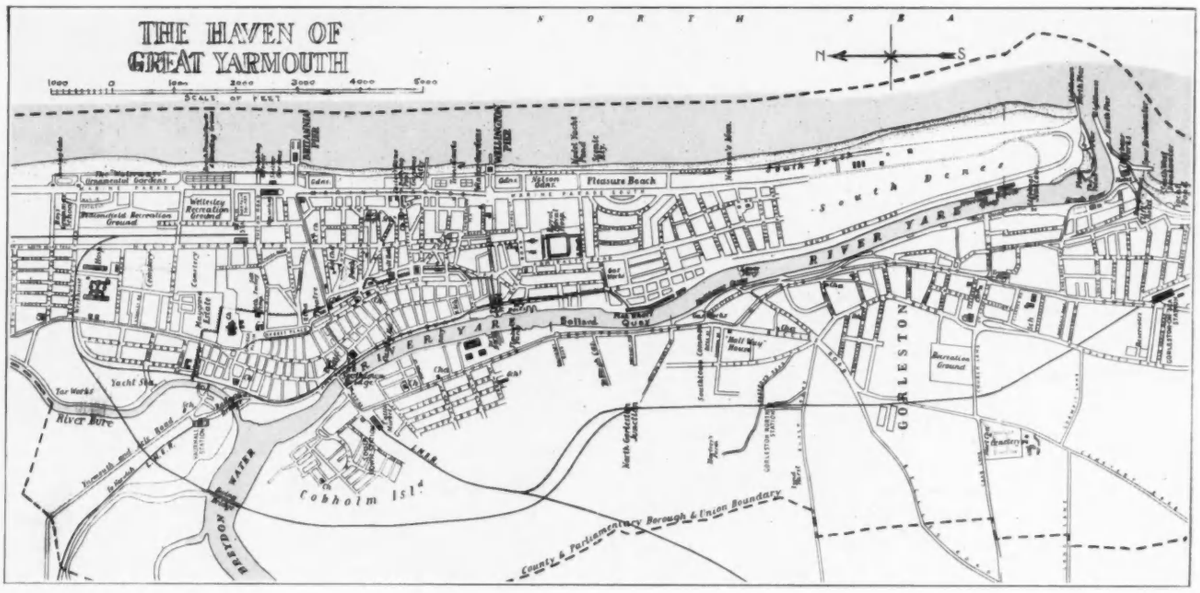
In view of the changes that are taking place in air transport and the possibility of a Trans-Tasman Air Service between Australia and New Zealand, the Board, with the Wellington City Council and the Wellington Chamber of Commerce, has taken steps to bring before the proper authorities the advantages Wellington Harbour offers for the landing and taking off of flying-boats. The Harbour Board has, on several occasions, received favourable reports as to the suitability of Wellington Harbour as a base for flying boats, and this view was confirmed in a statement by Mr. Harold Gatty of the Pan-American Airways: "that this harbour offers landing and take-off reaches and sheltered base waters equal to those of almost any other port in the world."

The Prime Minister, the Right Honourable M. J. Savage, having stated to a deputation from the Board, the City Council, and the Chamber of Commerce, that he considered Wellington to be the logical terminal for a point of distribution of mails and passengers, provided expert opinion of the harbour was favourable, the Board felt that Wellington Harbour should receive favourable consideration as the landing-place in New Zealand for the proposed Trans-Tasman Air Service. It is understood that the Government intends to obtain further expert opinion as to the suitability of the harbour as a flying-boat base.

The Port of Yarmouth

The World's Premier Herring Fishery Port

By RICHARD LEE BARBER, Chairman of the Great Yarmouth Port and Haven Commissioners



Jurisdiction

THE Port of Yarmouth is controlled by the Great Yarmouth Port and Haven Commissioners under the Great Yarmouth Port and Haven Acts and Order, 1866 to 1924, and it comprises the Haven and the Rivers Yare, Bure and Waveney, emptying themselves into the Haven and the navigable branches of these rivers respectively.

The limits of the Haven comprise all parts of the River Yare from its falling into the sea at the mouth thereof to the eastern extremity of Breydon and Burgh Flats.

The Commission consists of nineteen members who are triennially appointed or elected by the Corporations of Yarmouth and Norwich, Justices of the Peace for the Counties of Suffolk and Norfolk and shipowners and toll payers and one by the yachtowners respectively.

As shown on the plan there are two piers at the entrance to the Port of Yarmouth, which is 2½ miles in length from the entrance to the Southtown or Haven Bridge. This area includes over 5 miles of quayage. A photographic view of the harbour entrance is given on page 309.

Cranes, Yarmouth Quay

Accommodation

Excellent accommodation has been made at various quays in the Haven for the safe and more convenient discharge of vessels. The Bollard, or timber, quay, situated on the west side of the river measuring over 1,300-ft. in length, has been reconstructed in recent years and constitutes an ideal quay for the landing and storage of timber and other goods. Deep water berths are provided at the Town, East and Bollard Quays, where there is a depth of from 12 to 16-ft. at low water with a tidal range of 6-ft.

In addition to a 23-ton stationary electric crane on the South, or Town, Quay, there are two modern 5-ton electric jib cranes with railway sidings adjacent for dealing with bulk cargoes coming to the port for either rail or water—these cranes discharge a cargo of 650 tons of coal into lighters in four hours.

On the East Quay there are seven covered fish markets (including one trawl and two fresh herring export markets) totalling in length 1,900-ft. which afford excellent facilities for the carrying on of this important trade of the port and in close proximity to these markets there is ample storage accommodation for many thousands of boxes and other fishery stock used by merchants.

In addition to its being an important commercial port, Great Yarmouth is a popular seaside resort, where many thousands of visitors and residents are attracted by the facilities provided for river and sea excursions.

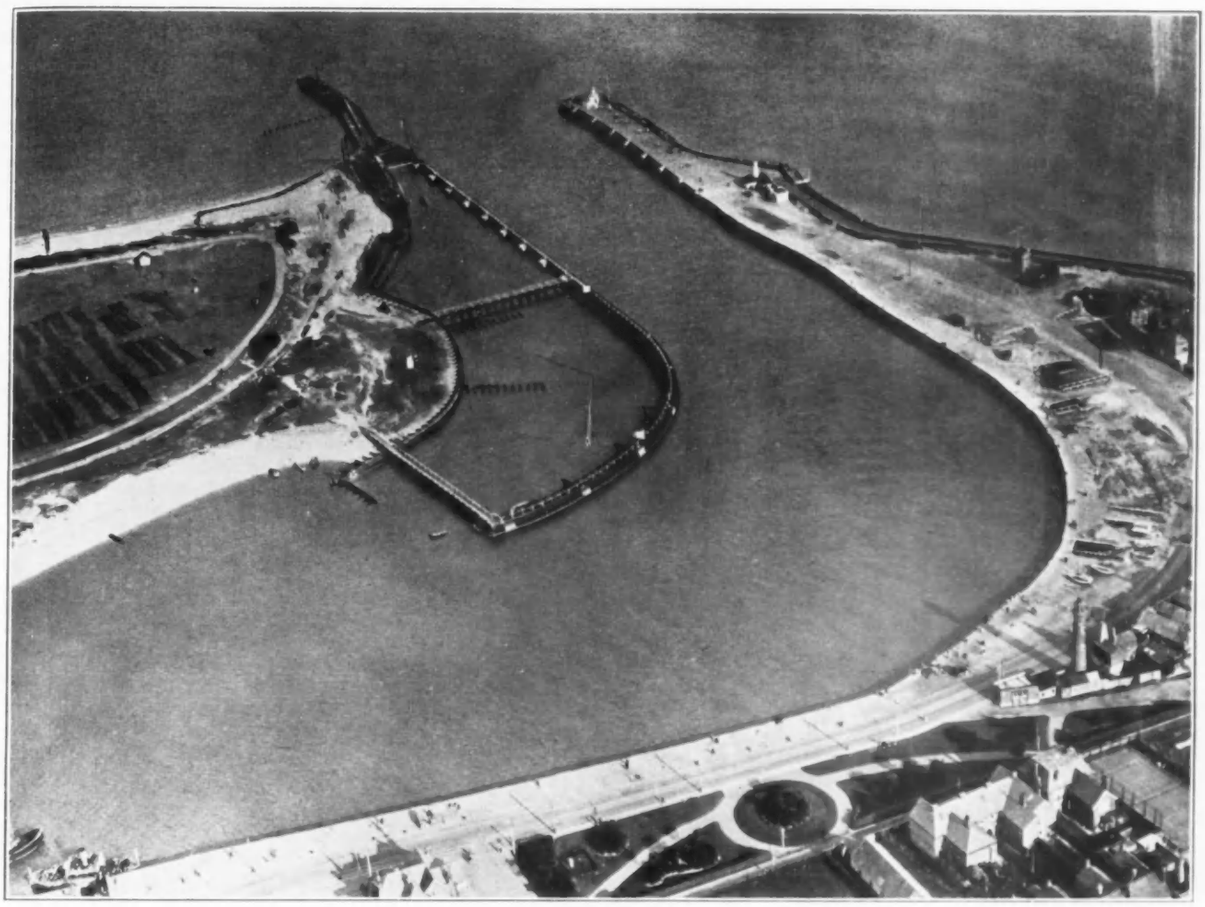
Passenger Services

During the summer season regular services are provided to inland beauty spots and also to Lowestoft (a neighbouring port) and to the Continent.

A new motor vessel, the "Queen of the Channel," 255-ft. in length, owned by the New Medway Steam Packet Co., Ltd., was last year put on the latter service for day return trips. So popular the venture proved, that for this present (1938) season two vessels are to be engaged, the "Queen of the Channel" being joined by the "Royal Sovereign," a modern motor vessel belonging to the same Company, of 275-ft. in length.

In addition to the day return passenger facilities available in 1937, permission has now been granted by the responsible bodies, i.e., the Immigration Department of the Board of Trade, H.M. Customs and the Special Branch of Scotland Yard, for the conveyance of week-end and period passengers and also for foreigners to visit this country through Great Yarmouth. This extension of the service has necessitated the provision on the part of the Harbour Commissioners, of a special suite of offices and rooms for the accommodation of various departments concerned. Thus the port has been added officially to the list of Approved Ports in Schedule II. of the Aliens' Order.

Port of Yarmouth—continued



Great Yarmouth—General View of Entrance

Trade

Regular steamship services run to the port from London, Hull and the Continent, the latter serving not only the port but inland towns, particularly the City of Norwich.

The principal imports are coal, groceries, grain, seeds, oil cakes, granite, fishery salt, wood, manure, iron and steel. The principal exports are malt, scrap metals, pickled and fresh herrings.

Fishery Industry

Any reference to the Port of Yarmouth would be incomplete without a special word regarding the herring fishing.

Great Yarmouth is the premier herring port of the world and it would perhaps be of added interest if in this article I dealt, inadequately perhaps, with the activities of the herring fishing as carried on during the autumn season and in order to show its extent certain illuminating facts and figures are given.

The number of steam and motor drifters (Scotch and English) working in and out of the port during the fishing season averages about 600; of these just over 400 come from Scotland.

Bollard Quay

This fleet, from the beginning of October to the end of November, incessantly goes to and from the fishing grounds, which are situated some 20 to 25 miles away from the port, in search of herrings and, in the course of a season, each drifter makes a good many trips to the harbour and when it is remembered that a large percentage of these craft is capable of bringing in at least 200 crans of herring (roughly 1,000 herrings go to the cran) the huge catching capacity of the fleet operating from the port will be easily gauged.

During the season of 1937, 356,822 crans of herring were brought in by this fleet, which gives the reader some indication of the enormous value of the " herring " as an article of food.

Most of the herrings when landed are put into swills (large open baskets), and taken by motor lorries into curing yards and there gutted and packed into barrels with brine, while some are exported in their fresh state to Germany and a proportion cured for home consumption. " Yarmouth Bloaters " and " Yarmouth Kippers " are well known throughout the length and breadth of the world.

As regards prices, these vary: the average price last season per cran was 25s. 8d.

As before-mentioned the greater part of the catch is cured and put into barrels, a branch of the industry carried on by the Scotch curers only, and last year no less than 325,760 barrels were dispatched, the chief export markets being Stettin, Danzig, Konigsberg, Riga, Gdynia, Klaipeda and Murmansk.

For the purpose of this curing and pickling industry the Scotch curers bring down a large staff of girls to gut the herrings prior to their being placed into barrels; the handling of these wet, cold, slippery fish during the coldest part of the year is a task which calls for only the strongest and fittest, yet the highland girls are always singing away merrily and making light of their work, which, let it be stated, often demands long hours.

In addition to the women workers, " coopers " are necessary. These men place the herrings when gutted into barrels, pickle them and prepare them for export. Other workers include carters and labourers.

Up to date facilities have been provided by the Great Yarmouth Port and Haven Commissioners, a progressive body of capable business men, for what is known as the "Klondyking" i.e., the placing of herrings brought in by the drifters direct into

Port of Yarmouth—continued

wooden boxes, lightly sprinkled with ice and salt and exported without delay, so that these herrings are abroad, comparatively speaking, in their fresh state.

The industry, irrespective of the direct employment of fishermen, affects other branches of commerce and coal is an essential requirement; while for the motor drifters oil fuel is supplied. Fishery salt is a necessity and each year a considerable quantity is imported specially for the use of the fishing.

Perhaps many readers have visited this famous seaside resort during the summer months to enjoy the invigorating air and beautiful golden sands, of which this East Coast town boasts, but it would be well worth while to visit Yarmouth during the autumn herring fishing season, as it would give an opportunity of witnessing one of the most fascinating sights that any industry can provide and of observing how wonderfully the 600 craft are controlled in this fine harbour at Great Yarmouth.

Next to the fishing industry the timber and coal trade form the chief source of revenue; 100,717 loads of the former and 244,085 tons of the latter having come into the port during the year, a considerable quantity of grain and seeds are also imported and exported.

There are two dry docks situate on the west side of the Haven, belonging to Fellows and Co., Ltd., one capable of taking steamers up to 270-ft. in length, 12-ft. draft and width of 35-ft.; the other, vessels of 255-ft. in length, width of 41-ft. and 14-ft. draft. Each dock is divided by middle gates in order that smaller vessels can be shut in for repairs. All kinds of ship repairing work is undertaken by skilled mechanics.

Connected with the port, as already mentioned, are the Rivers Yare, Bure and Waveney; the first-mentioned river is used considerably by commercial vessels and in a lesser degree by pleasure craft, but the other two rivers, Bure and Waveney, the former particularly, are extensively used by pleasure vessels. A visit to these with their spacious adjacent Broads affords pleasure to thousands of holiday seekers.

Otago Harbour Board, New Zealand

Excerpts from the Chairman's Annual Report for the Year ended September 30th, 1937

Trade and Shipping

The volume of trade which passed through the port last year amounted to 452,215 tons, which more than equalled the pre-depression years 1929-30 (425,083 tons) and 1928-29 (445,671 tons). An increase in imports of nearly 35,000 tons, of which 27,500 tons is from coastal and inter-colonial ports, is mainly responsible for this satisfactory position. Exports also showed an increase, though small.

A record for the port was established in shipping arrivals, these totalling 1,186,107 tons net register; the tonnage of oversea vessels increased by some 25,000 tons over last year which was a record at 754,730 tons; inter-colonial tonnage increased by 27,000 tons, and coastal by 16,000 tons.

Revenue and Expenditure

In view of the substantial increases in cargo and shipping, there was of necessity a considerable increase in our revenue, which reached the record figure of £193,119. Thanks to the buoyant revenue, the Board was able, in spite of rising costs, to prosecute its heavy programme of harbour improvements, and at the same time to transfer £10,750 to special reserve funds and to make a substantial special contribution to the sinking fund of the dredge " Otakou " loan.

After allowing for interest on loans, sinking fund contributions, loan repayments and depreciation of plant, an excess of income over expenditure of some £10,706 is shown, this being a substantial improvement on all the years back to 1928-29.

Works in Hand

The widening of the north side of Bowen Pier, Port Chalmers, was completed, thus giving an effective deep water berth at this pier.

The reconstruction of Birch Street Wharf, Dunedin, was commenced and is proceeding steadily. The new wharf on which there are crane rails and three railway tracks is a substantial structure and when completed will be a decided adjunct to the port, and will be more so when cranes are installed.

The reclamation of the 45-acre area on the Southern Endowment is practically completed, but will take some time to consolidate.

A work of special importance was the installation of suction gear on dredge " Otakou " with a view to dredging at the harbour entrance.

The work was designed and carried out by the Board's engineering staff and reflects great credit on the engineer and his assistants, who at a comparatively small cost have equipped the dredge with gear suitable for dredging in a seaway. The work carried out by the dredge since being fitted with the additional equipment has been most effective.

Harbour Boards Employees' Union

Of particular importance to Harbour Boards has been the registration during the past year of the N.Z. Harbour Boards Employees' Union, and the subsequent formation of the N.Z. Harbour Boards Employers' Union. The formulation of an award covering the employees of all Harbour Boards has been a task of considerable magnitude, especially in view of the varying conditions at the different ports.

The Report is signed by Mr. W. Begg, the Chairman.

Port of London Registration Committee

Excerpts from the Annual Report for the Year ended December 31st, 1937

In last year's Report the Committee drew attention to the considerable progress in London towards greater regularisation of Port employment. During 1937, however, the average unemployment of Registered Port Workers was still further reduced to 4,230 as compared with 7,836 in 1932, representing an improvement of approximately 46 per cent.

No system for securing individual records of employment is yet in operation in the Port of London, but the following statement prepared from statistics furnished by the Ministry of Labour will indicate the progressive reduction in the average unemployment of Registered Port Workers during the past four years, and corresponding improvement in the employment position.

	1934	1935	1936	1937
January	5,289	4,919	3,605	3,255
February	6,064	5,919	4,863	4,240
March	6,558	6,666	6,058	4,461
April	6,581	6,812	6,083	4,518
May	7,565	5,719	5,680	4,810
June	6,809	6,043	5,261	4,719
July	5,797	5,439	4,775	4,913
August	5,877	5,682	5,072	4,624
September	5,732	5,812	4,683	4,144
October	5,778	4,794	4,404	4,309
November	5,152	4,113	3,475	3,614
December	3,970	3,879	3,187	3,149
Average figures for the 12 months	5,931	5,483	4,762	4,230

The Registration Scheme provides for preference in employment to be given to Registered Port Workers, and with the active co-operation of Employers and Trade Union Representatives, it has been possible to secure the observance of this principle except at times of emergency when, on account of unpredictable fluctuations in the volume of employment, there has been an insufficiency of Registered labour. At such times, labour shortages have had to be made good by the engagement of " unregistered " workpeople who visit the docks in the hope of an odd day's work. During 1937 the number of such engagements tended to increase, largely on account of temporary maldistribution caused by seasonal and other periodical rushes of work. In London, however, the absorption of surplus Registered Port Workers is always a matter of great difficulty because of the extensity of the docks areas and lack of adequate transport facilities.

The Report is signed by W. L. Wrightson and T. W. Condon, Joint Chairmen.

New Dry Dock for Shanghai.

It is reported that the Japanese authorities have decided upon the construction of a large new graving dock at Shanghai. Particulars as to size and estimated cost are not published.

SITUATIONS VACANT

Technical Assistant for Tel Aviv Harbour

Applications are invited for the position of Technical Assistant in the Management of Tel Aviv Harbour.

Applicants should possess practical knowledge of harbour engineering and management. Qualified harbour engineers will be preferred.

Applicants should give full details of theoretical and practical antecedents, and should indicate salary required.

Applications to be addressed to the General Manager, The Marine Trust Ltd., P.O.B. 6041, Tel Aviv, before the 15th August, 1938.